Expansion of Confined Disposal Facilities

APPENDIX F2

GEOTECHNICAL DESIGN APPENDIX

U.S. Army Engineer District, Buffalo • 1776 Niagara Street • Buffalo New York 14207

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Attachments

A▶INTRODUCTION

Future dredged disposal in Toledo Harbor may be accommodated by reconfiguring and raising Toledo CDF. This report is divided into three parts. The first part (*Sections B.2 and B.3*) discusses possible future dredged material storage requirements and varying site configurations for a raised Toledo CDF. In each of six cases, capacity of the raised, reconfigured CDF is assessed. The second part (*Section B.4*) provides dike raising design information. The third part (*Section B.5*) includes construction considerations and concerns.

B▶DREDGED DISPOSAL CAPACITY SCENARIOS

Six different cases were developed for Toledo CDF which portray potential future dredged material management in Toledo Harbor. These are based on three different dredged material disposal rates and two different CDF configurations. Details are discussed in the following sections.

1. Dredged Material Storage Requirements

Three different annual dredging rates for material requiring confinement have been identified. These are assumed to be valid for the indefinite future. In each case, the annual dredging rate is assumed to be 600,000 CY/YR from 1996 to 2000. Then, depending on the case, the rate either increases (*Case 1*), remains the same (*Case 2*), or decreases (*Case 3*).

1a. Case 1 - Increased Rate

This case assumes that the annual amount of dredged material requiring confinement will increase from 600,000 CY to 850,000 CY after 2000. This represents the case in which all material dredged will require confinement, a significant increase in required capacity. No open lake dumping will be allowed in this case.

1b. Case 2 - Current Rate

This case assumes that the annual amount of dredged material requiring confinement will remain at the current rate of 600,000 CY. The current practices for confinement and open lake dumping will be maintained.

1c. Case 3 - Decreased Rate

This case assumes that the annual amount of dredged material requiring confinement will decrease from 600,000 CY to 350,000 CY after 2000. This represents a case in which some of the dredged material currently requiring confinement will be open lake dumped, resulting in a significant reduction in required capacity.

C▶CAPACITY ASSESSMENT

1. General

The capacity of each raised CDF scenario has been estimated. This was done by applying the respective annual dredged material confinement rates to each of the two CDF configurations. The consolidation of the freshly placed dredged material was determined in *Appendix A*. For each case, the following factors were taken into consideration: existing capacity in Cell 1; existing capacity in Cell 2; increased capacity of the raised CDF configuration (A or B); and capacity enhancement due to excavation of existing dredged material for use in raising the CDF. *Section A.3.6* summarizes the results of this capacity assessment.

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Figure 1

SECTION B-B

SECTION A-A

Toledo Confined Disposal Facility
Disposal Facility Raising Decision
CONFIGURATION A

Figure 2

SECTION B-B

SECTION A-A

Toledo Confined Disposal Facility
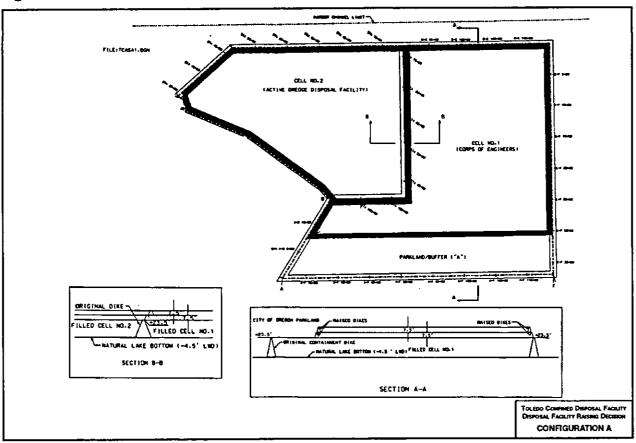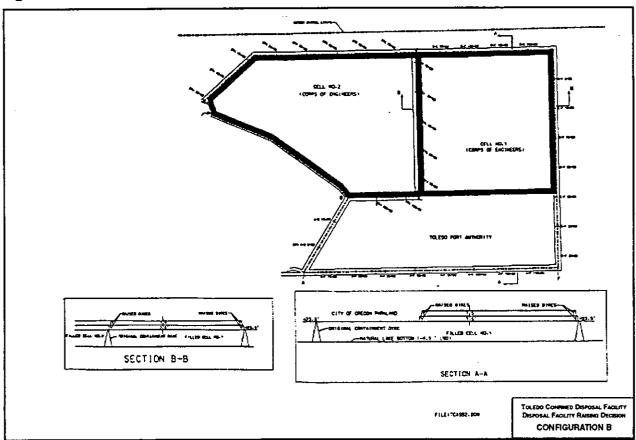Disposal Facility Raising Decision
CONFIGURATION B

2. Assumptions

The following assumptions were used in the capacity assessment process:

- The clock, or time dredged placement begins, starts for each case in 1996, to match the computer simulations
- In each case, the CDF is raised a total of 15 feet; as a matter of practicality, the raising will be accomplished in two equal lifts of 7-1/2 feet each (see *section B.5.3*)
- Each raising increment (first and second) is required just before capacity of the respective CDF configuration is reached (i.e., the dikes are not raised until additional capacity is necessary)
- Existing capacity of Cell 1 is based on estimates based on recent Buffalo District surveys
- Consolidation of the freshly placed dredged material is based on the computer simulations in Appendix A
- Annual dredging rate between 1996 and 2000 is assumed to be the current rate (650,000 CY)
- Annual dredging rates for each case/scenario are assumed to be constant over the full period of placement prior to filling the raised CDF after the year 2000
- The raised CDF is considered to reach capacity when the surface of the consolidated dredged fill reaches within two feet of the

Figure 3. Dredging Scenarios Matrix

	Configuration	
ANNUAL DREDGING RATE (CY)	**A**	**B**
	(Set Aside 20% of Cell 1 for Linear Park)	(Set Aside 45% of Cell 1 for Recycling)
	CASE A1	**CASE B1**
850,000	(Cell 2 Full 111 2005; Raise Cell 1 in 2004)	(Cell 2 Full in 2005; Raise Cell 1 in 2004)
	CASE A2	**CASE B2**
600,000	(Cell 2 Full in 2008; Raise Cell 1 by 2007)	(Cell 2 Full in 2008; Raise Cell1 by 2007)
	CASE A3	**CASE B3**
350,000	(Cell 2 Full by 2016; Raise Cell 2 by 2015)	(Cell 2 Full by 2016; Raise Cell 1 by 2015)

- The raised CDF is considered to reach capacity when the surface of the consolidated dredged fill reaches within two feet of the crest elevation (to allow freeboard)
- For those cases in which CDF capacity is reached prior to the arbitrary target year 2025, the additional capacity required to year 2025 has been determined
- For those cases in which capacity remains beyond 2025 for the raised CDF, the year in which capacity is reached for that configuration has been determined
- A reduced footprint resulting to telescoped construction of the upper lift for each raised CDF is made
- The basic character of the incoming dredged material will not change over the period of placement
- The dredged material fills the available CDF space in a level manner without highs or lows, which maximizes the available space in each case
- Beneficial results of trenching/dewatering are incorporated into the capacity assessment

3. Rationale

The following rationale was used to assess the capacity of each case:

- Existing capacity in Cell 1 is exhausted
- When Cell 1 is filled, dredged material will be placed into Cell 2
- Cell 1 will be raised for the first time (7-1/2 feet) when required (i.e., Cell 2 capacity is exhausted)
- Dredged material placement will be shifted to Cell 1
- Cell 2 will be raised for the first time when the capacity of the raised Cell 1 is exhausted
- The process is repeated for a second cycle of raising each cell independently
- For each case, the assessment is carried out to the year 2025; in some cases, the capacity of the raised Cells 1 and 2 is sufficient through 2025, in which cases the capacity is assessed until the twice raised CDF is full; in other cases, there is a deficiency in capacity to 2925; the deficient amount of capacity is reported

4. Configuration A Cases

4a. Case Al

Case Al is depicted by *Figure B4*. This includes the City of Oregon linear park and the increased rate of dredged material confinement (850,000 CY/YR). According to this assessment, the cross dike separating the linear park from the adjoining CDF must be constructed by the year 2002. Cell 1 must be raised for the first time by the year 2004, and Cell 2 by 200. The second raisings for each cell are required by, respectively, 2010 and 2013. Final capacity will be reached by 2016. An additional 6,400,000 CY must be confined to reach 2025 under this case.

4b. Case A2

Case A2 is depicted by *Figure B5*. This includes the City of Oregon linear park and the current rate of dredged material confinement (600,000 CY/YR). According to this assessment, the cross dike separating the linear park from the adjoining CDF must be constructed by the year 2005. Cell 1 must be raised for the first time by 2007, and Cell 2 by 2012. The second raisings for each cell are required by, respectively, 2016 and 2021. A marginal amount of capacity will remain in the CDF in 2025, with this case filled to final capacity by 2026.

4c. Case A3

Case A3 is depicted by *Figure B6*. This includes the City of Oregon linear park and the decreased rate of dredged material confinement (350,000 CY/YR). According to this assessment, the cross dike separating the linear park from the adjoining CDF must be constructed by the year 2013. Cell 1 must be raised for the first time by the year 2015, and Cell 2 by 2023. Due to the reduced annual rate of confinement, this case requires only a single raising of both cells to provide capacity to year 2025. The assessment was extended to raise Cells 1 and 2 a second time in years 2030 and 2046, respectively. Final capacity will be reached by 2046. In this case, since the cells will not require raising and re-raising for extended periods of time, capacity is enhanced additionally by consolidation of the freshly placed dredged material. This is not possible in Case Al, for example, since the raising cycle is almost continuous. Therefore, a modest but reportable gain in capacity due to consolidation settlement is realized.

4d. Case Bl

Case Bl is depicted by *Figure B7*. This includes the reduced Cell 1 and the increased rate of dredged material confinement (850,000 CY/YR). According to this assessment, Cell 1 must be raised for the first time by 2004 and Cell 2 in 2006. The process must be repeated in 2008 and 2010, respectively. Final capacity of the fully raised CDF will be reached in 2012. An additional capacity of 9,300,000 CY must be confined to reach 2025 under this case.

4e. Case B2

Case B2 is depicted by *Figure B8*. This includes the reduced Cell 1 and the current rate of dredged material confinement (650,000 CY/YR). According to this assessment, Cell 1 must be raised for the first time in 2007, and Cell 2 in 2011. The process must be repeated in 2015 and 2019, respectively, with overall capacity reached in 2023. An additional 1,000,000 CY must be confined to reach 2025 under this case.
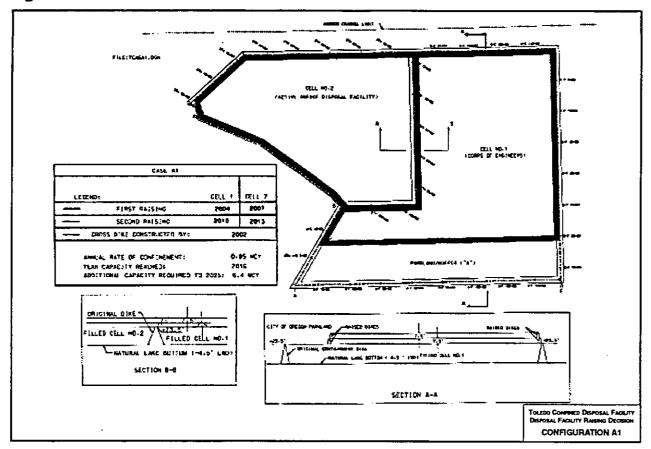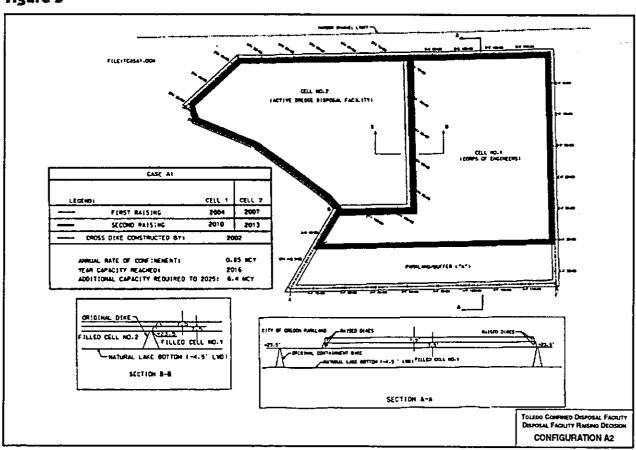
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Figure 4

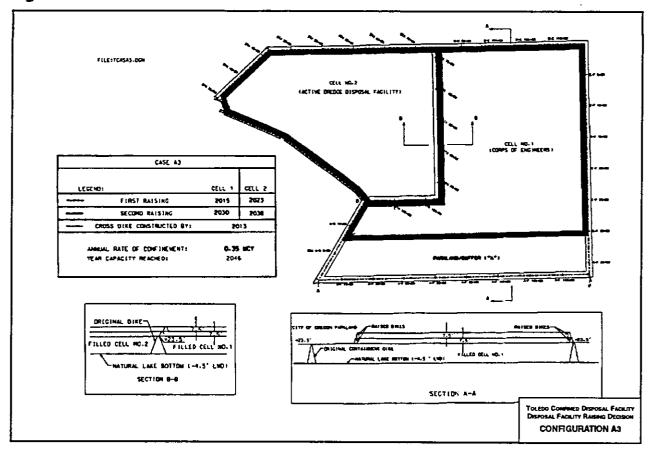Toledo Confined Disposal Facility
Disposal Facility Raising Decision
CONFIGURATION A1

Figure 5

Toledo Confined Disposal Facility
Disposal Facility Raising Decision
CONFIGURATION A2

Figure 6

Toledo Confined Disposal Facility
Disposal Facility Raising Decision
CONFIGURATION A3

Figure 7

Toledo Confined Disposal Facility
Disposal Facility Raising Decision
CONFIGURATION B1

Figure 8

CASE B2

LEGEND:	CELL 1	CELL 2
FIRST RAISING	2007	2011
SECOND RAISING	2015	2019

ANNUAL RATE OF CONFINEMENT: 0.6 MCY
YEAR CAPACITY REACHED: 2023
ADDITIONAL CAPACITY REQUIRED TO 2025: 1.0 MCY

SECTION B-B

SECTION A-A

FILE:TCASB2.DGN

TOLEDO CONFINED DISPOSAL FACILITY
DISPOSAL FACILITY RAISING DECISION
CONFIGURATION B2

Figure 9

CASE B3

LEGEND:	CELL 1	CELL 2
FIRST RAISING	2019	2021
SECOND RAISING	2028	2034

ANNUAL RATE OF CONFINEMENT: 0.35 MCY
YEAR CAPACITY REACHED: 2042

SECTION B-B

SECTION A-A

FILE:TCASB3.DGN

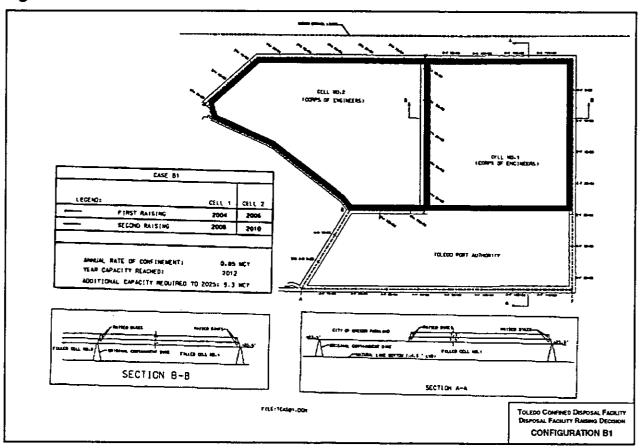TOLEDO CONFINED DISPOSAL FACILITY
DISPOSAL FACILITY RAISING DECISION
CONFIGURATION A
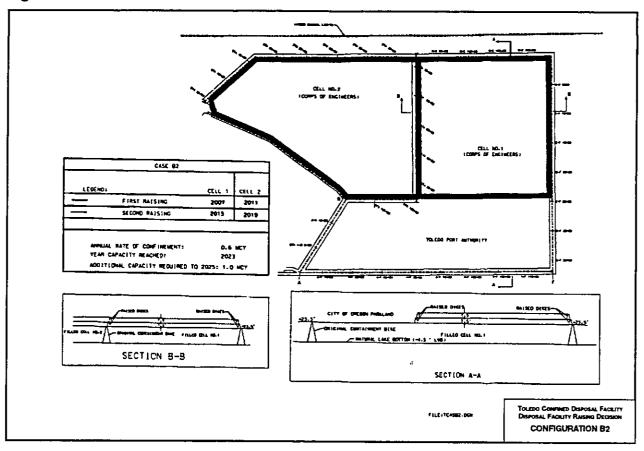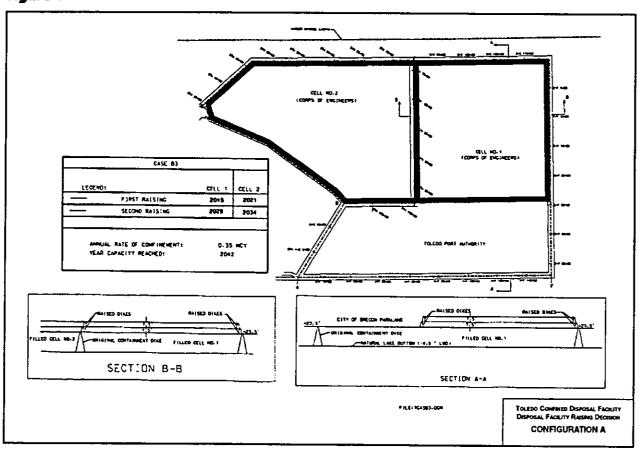
4f. Case B3

Case B3 is depicted by *Figure B9*. This includes the reduced Cell 1 and the reduced rate of dredged material confinement (350,000 CY/YR). Cell 1 must be raised for the first time in 2015, and Cell 2 in 2021. due to the reduced rate of confinement, only a single raising of each cell is required To provide capacity to 2025. The assessment is extended by raising Cells 1 and 2 in 2020 and 2034, respectively. Final capacity will be reached in 2042. As in Case A3, the reduced rate of confinement increases the time between raising each cell significantly, resulting in a meaningful increase in capacity due to consolidation settlement.

5. Summary of Capacity Assessment

These six cases, which include two different CDF configurations and three different filling rates, offer a wide range of capacities for dredged material placement projected well into the 21st century. The preferred configuration is Case A, which provides a larger CDF than B. The actual filling rate over the life of the raised CDF is still unknown at the time of this report, subject to future decision. Based on the capacity analyses, the full confinement case (1) greatly compresses the useful life of this raised CDF, which requires additional capacity from some other facility beyond 2012-2016. Due to the minimal time between raising each cell, little beneficial consolidation of the dredged material is anticipated. The reduced confinement case (3) greatly expands the useful life of this CDF, due to the greatly reduced filling rate as well as additional capacity gained due to consolidation of the fill which has significant "fallow time between dike raisings. The CDF life under these conditions ranges from 2042 to 2046. At the current rate of filling (*Case 2*), the raised CDF will satisfy future dredged placement needs to around 2025. Moderate benefits can be derived from consolidation of the dredged fill between raising each cell in this case.

▶DESIGN OF RAISED PERIMETER DIKES

1. General

This section presents the geotechnical design analysis of the raised perimeter dikes. The geotechnical design analysis consisted of the following types of analysis: (a.)Stability of the perimeter dikes against foundation shear failure, (b.)Bearing capacity of the dredge fill foundation due to imposed loads from the perimeter dikes, (c.)Settlement of perimeter dike and time rate of consolidation of the perimeter dike foundation. Also presented is a preliminary design of the perimeter dike access road.

2. Borrow Material Characteristics

Borrow material for perimeter dike construction will be from the dredge spoil contained in cells 1 and 2. Based upon test pits dug in cell No.1 (Gilbert, 1995) the dredge spoil consists primarily of fine grained material and according to the Unified Soils Classification System were classified as high plastic clay (CH). One sample tested was classified as a low plastic silty clay (CL) thus indicating the random nature of the soils placed in Cell No.1. It is likely that material plasticity is higher in the vicinity of the weir since less plastic soils are characterized by larger particles that will settle through water and be deposited at greater distances from the weir (Gilbert, 1995)

Silty clay (CL) soils are ideal for perimeter dike construction as they are nearly impervious (i.e. have very low permeability), are fairly stable, and have good compaction characteristics. High plasticity clays are also nearly impervious and have fair stability when used on flat slopes but have detrimental shrinkage characteristics which may necessitate blanketing or incorporating them in interior cores of embankments (TM No. 3-357). In addition, high plasticity clays have fair to poor compaction characteristics. As discussed in the previous paragraph it likely that less plastic soils would be found at greater distances from the weir thus, for the reasons discussed above it may be necessary to zone the embankment with the high plasticity clays in the core and the less plastic clays on the outside.

No compaction tests were performed on the dredge spoils in Cell No.1. However, during the construction of the impervious portions of the Cell No.1 and Cell No.2 containment dikes, compaction test were performed on the impervious borrow soils which were obtained from the Edison Dike Disposal Site dredge spoils located adjacent to Cell No.1 and Cell No.2. Results of the compaction tests revealed that the optimum dry densities varied from 107 pcf to 114 pcf and optimum moisture contents varying from 14% to 19%.

3. Previous Experiences

A dike raising demo project was completed in 1995 in Cell 1 which provided earthwork construction experience involving available dredged material. No special arrangements were made regarding the borrow material. It was simply excavated from around the perimeter of the demo area. Depth of excavation was limited to a maximum of about three feet. The low demo dike was built using two construction machines. An excavator dug up the borrow and placed it in a windrow. A small dozer completed the berm by running over the windrow, to densify the material, and shaping it to the desired crossection. No special problems were encountered in this case. The demo was situated in a mature part of Cell 1. A fairly thick crust was encountered. The borrow material was most likely well above optimum moisture content, but proved to be workable. The demo berm performed well, without stability or seepage problems.

Previous dike raising was done in Cleveland Dike 14, from the late 1980's into the early-mid 1990's. A demo berm was completed in 1989. This consisted of a 400 foot long variable crossection. The berm was constructed out of available dredged material (silty sand). A seven foot high berm was successfully completed using a dozer and dump trucks. This proved to be stable in various configurations (with and without geofabric reinforcement). This served as the prototype for three subsequent dike raising projects in Dike 14. In each case, select dredged material (sand) was used until locally exhausted. All three dike~ raising projects were successful in terms of stability, seepage, and constructability. The Dike 14 raising experience provided a basis for raising Toledo Cell 1 up to 7-1/2 feet per raising. This has yet to be verified by actual construction in Toledo CDF. However, previous experience indicates the Toledo CDF raising should be feasible and constructible using available borrow and conventional equipment. The most likely cause for concern is availability of sufficient borrow which is workable (i.e., dry enough). It may be necessary to stockpile borrow in advance of construction to guarantee a sufficient supply for the planned dike raising work.

4. Geotechnical Design Parameters

This section presents the geotechnical design parameters used in the stability, bearing capacity and, settlement analysis of the raised perimeter dikes. The stability and bearing capacity design parameters are summarized in *Table 1*. The settlement design parameters are summarized in *Table 2*. The rationale for obtaining these design parameters are presented in *Attachment 1* at the end of this appendix.

Table I - Stability Design Parameters

Material Type	Unit Weight sat pcf	Unit Weight mst pcf	Q Test Values c psf	Q Test Values 0 deg	R Test Values c psf	R Test Values 0 deg	R-Bar Test Values c psf	R-Bar Test Values 0 deg
Dredge Fill Foundation	102	100	400	0	200	16.0	0	28
Raised Dike Embankment Fill	131	125	1000	0	800	25	560	35
Original Dike Embankment Fill	131	125	1000	0	800	25	560	35
Original Dike Prepared Limestone	146	137	-	-	-	-	0	35
Original Dike Riprap	126	105	-	-	-	-	0	40
Lake Bottom Foundation (Medium clay)	127	122	600	0	400	16	200	30
Lake Bottom Foundation (Medium - Stiff)	133	128	840	0	500	18	300	32
Lake Bottom Foundation (Stiff - V. Stiff)	136	132	1200	0	800	20	500	36

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Table 2 - Settlement Design Parameters

Stratum	El. Top of Stratum	Drainage Condition	Effective Unit Weight (pcf)	Compression Index Cc	Recompression Index Cr	Void Ratio Eo	Coefficient of Consolidation Cv (Ft²/yr)
Very Soft Dredge Spoil	599.6	Double	37.6	.34	.08	1.6	10.1
Soft to Stiff Clay Foundation	564.1	Double	73.6	.12	.02	0.4	10.1
Bedrock	495.0	Incomp	97.6	-	-	-	-

5. Stability Analysis

A slope stability analysis was performed for the perimeter dikes using Corps computer program UTEXAS3. This program calculates the factor of safety for a prescribed failure surface or for a search of the critical failure surface. Both circular or non-circular (wedge) shear surfaces can be evaluated. Various methods of analysis can be used to compute the factor of safety of the failure surface including Simplified Bishop's method and Spencer's method.

A circular search for the critical failure surface was performed using the Spencer's method of analysis to compute the factor of safety. The following design conditions were analyzed:

(a.) End of Construction Stability of Perimeter Dike Embankment, Parkland Buffer Area.

(b.) Long Term Stability of Perimeter Dike Embankment, Parkland Buffer Area.

(c.) End of Construction Stability of combined Perimeter Dike Embankment and Original.Dike, Lake Side of Cell's No. 1 and No. 2.

(d.) Long Term Stability of combined Perimeter Dike Embankment and Original Dike, Lake Side of Cell's No.1 and No.2.

For design condition (c.) the soil design parameters for the natural foundation were adjusted to account for the effects of consolidation by the imposed load from the original containment dike. Corps computer program CSETT was used to determine the time rate of consolidation. Consolidation of the foundation soils were computed up to the time that the raised perimeter dikes were placed. The foundation undrained shear strengths were then determined using the estimated percent consolidation at the time of raised embankment placement. Computations for foundation undrained shear strengths are presented in Attachment Bi.

Figures 10 thru 13 show the locations of the critical failure surfaces and computed factor's of safety. *Table 3* summarizes the results of this analysis. Results of the analysis show that the raised perimeter dikes are stable and the computed factor's safety exceed the required minimum values (EM1110-2-1906). The computer input data and output is presented in *Attachment II*.

Table 3 - Summary of Stability Analysis Results

Design Condition	Computed Factor of Safety	Required Factor of Safety
a. End of Construction, raised perimeter dike, Parkland Buffer Area, parkland side	1.513	1.30
b. Long Term Stability, raised perimeter dike, Parkland Buffer Area, parland side	1.932	1.50
c. End of Construction, combined raised perimeter dike and original dike, lake side	1.443	1.30
d. Long Term Stability, raised perimeter dike and original dike, lake side	2.121	1.50

6. Settlement Analysis

The ultimate settlement and the time rate of settlement of the raised perimeter dike embankments were computed using Corps computer program CSETT. This computer program determines the settlement and time rate of settlement using Terzaghi's one-dimensional consolidation theory. The program provides for analyses of multiple soil layers and a variety of drainage conditions. The program determines the induced stress of simple or complex loading conditions and computes the resulting settlement of compressible soils.

The settlement design loading conditions are presented in *Figure 14*. The ultimate settlement of the raised perimeter is computed to be 1.586 feet and occurs at the centerline of the second raised dike. The time rate of settlement shows that 90% of the ultimate settlement is expected to occur in about 38 years after perimeter dike construction. The computer input data and output is contained in *Attachment II*.

7. Bearing Capacity

The bearing capacity of the dredge fill foundation from the imposed load of the perimeter dike embankment was computed using presented graphically in *Figures 15 and 16* and summarized in *Table 4*. The ultimate bearing capacity of the dredged fill foundation was computed to be 2056 psf and the factor of safety against bearing capacity failure for the telescoped raised perimeter dike is 2.432. The required factor of safety against bearing capacity failure is 2.0 (EM1110-1-1905).

To check the feasibility of raising the perimeter dike once (i.e. construct one 15 foot high perimeter dike as opposed to two 7.5 foot telescoping dikes) the factor of safety against bearing capacity failure due to the imposed load from this dike was also computed. Results of this analysis showed that the factor of safety against bearing capacity failure is 1.263 which is well below the required minimum factor of safety of 2.0. Thus, for this reason construction of a single raised dike is not feasible.

Table 4 - Dredge Fill Bearing Capacity Results

Design Condition	Ultimate Bearing Capacity (psf)	BC Factor of Safety	BC Required Factor of Safety
Double Dike Raising (Top Dike)	2056	2.432 (computer) 3.29 (hand)	2.0
Single Raised Dike	2056	1.263 (computer) 1.81 (hand)	2.0

8. Seepage Analysis

Since the perimeter dikes and foundation consists of fine grained impervious materials, t.iru seepage and under see page is not expected to be a problem. The recommended dike management technique of surface trenching will remove any ponded surface water and water in the upper crust of the dredged fill spoils.

9. Access Road Design

To accommodate vehicular traffic along the perimeter dike, the top dike will be widened to accommodate a 16 foot wide access road. The access road will consist of a 6' thick gravel base.

▶ CONSTRUCTION

1. General

The CDF will be raised in the same general manner in all cases. Existing dredged material will be borrowed from one cell or the other and incorporated into relatively low earthen berms. Earthwork construction criteria (moisture control, compaction) will be modest. Raising will be done in 7-1/2 foot increments, based on previous empirical experience. Specialized construction techniques and materials may be required to construct such features as access roads and weirs.

2. Construction Methods and Equipment

The dikes will be raised using conventional construction methods and equipment. Sufficient borrow material exists as dredged fill for use in raising the dikes a total of 15 feet. However, there may not be sufficient material which is dry enough to be excavated, hauled and placed to satisfy raising all of the dikes at one time. Harvesting" dredged material one or more construction seasons in advance of planned dike raising will help to provide sufficient quantities of good borrow. Based on past experiences, the borrow material can be adequately compacted by conventional, small dozers or similar equipment. Compaction will be accomplished by trafficking the construction equipment over the placed borrow. Material may be excavated by whatever method may be most practical, including drag line, pan, dozer, or excavator. Density and moisture control will be accomplished by visual inspection rather than testing. Reasonably precise vertical control will be required to ensure the raised dikes are built to the required crest elevation.

3. Phased Construction of Raised Dikes

Raising of Cell 1 and Cell 2 will be accomplished incrementally. Each cell will be raised a total of 15 feet in two equal increments of 7-1/2 feet. The second raising will be telescoped" to the inside of the previously raised dike. Also, each cell will be raised independently, as discussed in the capacity assessment sections of this appendix. It is important that each increment of raising be properly phased to meet projected dredged confinement requirements as well as so ample amounts of borrow material of useable quantity and quality be available when needed. It may be necessary, or at least desirable, to windrow part of one raising's allotment of borrow a season or more in advance of the required raising time, in order to improve constructability and availability of workable borrow.

▶ SUMMARY

1. General

This appendix presents strategies for raising Toledo CDF to meet future dredged disposal needs in Toledo Harbor well into the 21st century. It includes a detailed assessment of capacity under different scenarios of CDF configuration and dredged material confinement rates as well as raised dike design information and construction considerations.

2. Recommendations

Case A is the preferred alternative for the raised Toledo CDF, since it provides more available capacity for future dredged material confinement. The annual filling rate has not yet been determined. The best case would be A3, with a reduced future rate of confinement, which would maximize the life of the raised CDF. In any case, raising this CDF is considered to be a practical and realistic means to provide additional capacity from the existing Toledo CDF.

APPENDIX F2
GEOTECHNICAL DESIGN APPENDIX

ATTACHMENT 1
SOIL DESIGN PARAMETER DEVELOPMENT

▶ DREDGE FILL FOUNDATION

1a. Unit Weight

Table 1 summarizes density and water content test results conducted on dredge fill samples (Gilbert, 1995) with an average dry density of 62.5 pcf and average water content of 61.3% the moist density is computed as follows

$$\gamma mst = (1 + w).ry = (1 + .613) \times 62.5 = 100.8 \text{ pcf Say } \mathbf{100\ pcf}$$

The average void ratio is 1.718. Thus, the saturated density is computed as follows:

$$\gamma Sat = (G+e)w/(1+e) = (2.7+1.72) \times 62.5 \text{ pcf}/(1+1.72)\ 101\ 6pcf$$
$$\text{Say } \mathbf{102\ pcf}$$

1b. Unconsolidated Undrained Shear Strength (Q Test Strength)

Figure 1 shows the results of undrained shear strength of dredge fill with depth obtained from field vane shear test results (Gilbert, 1995). In the upper 11 feet the shear strength varies widely from a low of 300 pst to a high of 750 psf At depths below 11 feet the shear strengths varied from 400 psf to about 500 psf. Taking the lowest 1/3 of the test values the undrained shear strength is: **Su = 400 psf.**

1c. Consolidated Undrained Shear Strength (R Test Strength)

From Table 2-2 Bowles the CU angle of internal friction for a clay varies from 14° to 20° For a soft to medium clay assume **C = 200 psf, 0 = 16°.**

1d. Consolidated Drained Shear Strength (S Test Strength)

From Table 2-2 Bowles the CD angle of internal friction for clay varies from 20° to 42°. For a soft to medium clay assume **0 = 28°.**

▶ RAISED DIKE EMBANKMENT FILL

2a. Unit Weight

Optimum compacted dry densities obtained from compaction tests performed on the cell 2 disposal facility borrow site (Edison Dike Disposal Facility). Optimum dry densities varied from 107 pcf to 114 pcf. Optimum moisture contents varied from 14% to 19%. The reccomended dry density from TPO for these tests results is 109 pcf and the moisture content is 15%. Using these values the moist unit weight is computed as:

$$\gamma mst = (1 + w)\gamma dry(1 + .15) \times 109pcf = \mathbf{125pcf}$$

Table 1 - Consolidation Test Results

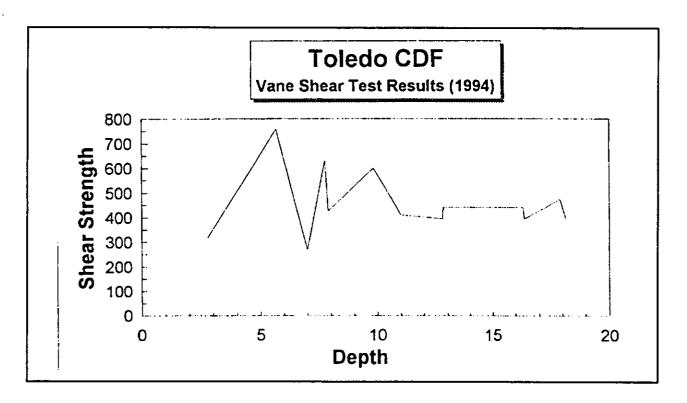| Location	Depth	Water Content	dry density	void ratio
Site 1	6.5	56.8	64.5	1.615
	9	52	70.7	1.386
Site 2	10	70.3	56.1	2.003
	13	66.1	58.8	.1867
Ave =		61.3	62.525	1.71775

Figure A

Toledo CDF
Vane Shear Test Results (1994)

Table 2. Representative values for angle of internal friction θ

Soil	Unconsolidated undrained UU	Consolidated undrained CU	Consolidated drained CD
Gravel			
Medium size	40-55°		40-55°
Sandy	35-5°		35-5°
Sand			
Loose dry	28.5-34°		
Loose saturated	28.5-34°		
Dense dry	35-46°		43-50°
Dense saturated	1-2° less than dense dry		43-50°
Silt or silty sand			
Loose	20-22°		27-30°
Dense	25-30°		30-35°
Clay	0° if saturated	14-20°	20-42°

* See a laboratory manual on soil testing for a complete description of these tests, e.g., Bowles (1970).

Table 3. Empirical values for q_u* and consistency of cohesive soils based on the standard penetration number

Consistency	Very soft	Soft	Medium	Stiff	Very stiff	Hard
q_u, ksf	0	0.5 (250)	1.0 (500)	20 (1,000)	4.0 2,000	8.0 4,000
N, standard penetration resistance	0	2	4	8	16	32
$\gamma_{(sat)}$, pcf (kN/m^3)		100-120 (16-19)		110-130 (17-20)		120-140 (19-22)

* These values should be used as a guide only. Local cohesive samples should be tested, and the relationship between N and the unconfined compressive strength q_u established as $q_u = KN$.

The saturated unit weight is obtained from the following relationship]

$$\gamma_{sat} = (G \pm e) \; \gamma_w/(1 + e)$$

Where the void ratio is obtained from the following.

$$G \; \gamma_w/(1+e) \gamma_{dry}$$

$$e = [G \gamma_w/\gamma_{dry}] - 1 = [2.7 \times 62.4/109] - 1 = 1.55 - 1 = 0.55$$

Thus:

$$\gamma_{sat} = (2.7 + 0.55) \times 62.4 \text{ pcf}/(1 + 0.55) = 131 \text{ pcf}$$

2b. Undrained Shear Strength (Q Test Shear Strength)

No shear strength values are available for compacted borrow for Toledo CDF. Assume that the compacted embankment fill has undrained shear strength comparable to a medium to stiff clay. From table 3-4 Bowles the undrained shear strength of a medium to stiff clay is **1,000 psf.**

2c. Consolidated Undrained Shear Strength (R Test Shear Strength)

No shear strength values are available for compacted borrow for Toledo CDF. Assume that the clay borrow for Toledo CDF has Consolidated Undrained Shear Strengths similar to the CU strengths obtained for the Ashtabula Landfill remolded compacted specimens which has a cohesion intercept $C = 800$ psf and angle of internal friction of $0 = 25°$.

2d. Consolidated Drained Shear Strength (S Test Shear Strength)

No shear strength values are available for compacted borrow for Toledo CDF. Assume that the clay borrow for Toledo CDF has Consolidated Undrained Shear Strengths similar to the CD strengths (R Bar) obtained for the Ashtabula Landfill remolded compacted specimens which has a cohesion intercept $C = 560$ psf and angle of internal friction of $0 = 35°$ This is consistent with the typical values found in Table 2-2 of Bowles for a clay in which the CD angle of internal friction varies from 20° to 42°.

▶3 ORIGINAL DIKE EMBANKMENT FILL

Assume unit weights and shear strengths are the same as the raised dike embankment fill]

▶4 ORIGINAL DIKE PREPARED LIMESTONE

4a. Unit Weight

From the the Toledo Cell No.2 nuclear density tests during construction the average dry density is 134 pcf which equates to M void ratio of .23 The saturated unit weight is computed as follows:

$$\gamma_{sat} = (G+e) \times \gamma_w/(1+e) = (2.65 + .23) \times 62.4 \text{ pcf}/(1 + 23) = 146 \text{ pcf.}$$

Assuming a moist water content of 2%, the moist unit weight is computed as follows

$$\gamma_{mst} = (1+w) \times \gamma_{dry} = (1 + .02) \times 134 \text{pcf} = 137 \text{pcf.}$$

4b. Undrained Shear Strength (Q Test Shear Strength)

This is a cohesionless, fairly well drained material. Therefor the undrained shear strength does not apply.

4c. Consolidated Undrained Shear Strength (R Test Shear Strength)

Same rationale as discussed in para 4(b.).

4d. Consolidated Drained Shear Strength (S Test Shear Strength)

From the Toledo Cell No.2 design analysis the drained angle of internal friction is $0 = 33°$ From Table 2-2 Bowles, the angle of internal friction for a sandy gravel varies from 35° to 50°. Since this material is expected to be loose when end dumped from self unloader assume the lower value of angle of internal friction of 35°

▶5 ORIGINAL DIKE RIPRAP STONE

5a. Unit Weight

Reasonable to assume that the porosity is 38%, thus the submerged density is computed to be:

$$\gamma_{sub} = (G-1) \times \gamma_w \times (1-n) = (2.65-1) \times 62.4 \text{ pcf} \times (1 - .38)$$

$$\gamma_{sub} = 63.8 \text{ pcf.}$$

The saturated unit weight is computed as: 63.8 pcf + 62.4 pcf = **126 pcf.**

The moist unit weight (assuming moisture content of 2%) is computed as:

$$\gamma_{mst} = (1+w) \times G \times \gamma_w \times (1-n)$$

$$\gamma_{mst} = (1 + .02) \times 2.65 \times 62.4 \text{ pcf} \times (1 - .38) = 105 \text{ pcf.}$$

5b. Drained Shear Strength

From Table 2-2 Bowles for a uniform size gravel the angle of internal friction varies from 40° to 55°. Assume that the riprap is similar to a loose medium uniform sized gravel and use the lower bound value of $0 = 40°$.

4

▶ 6 LAKE BOTTOM FOUNDATION (MEDIUM CLAY)

6a. Unit Weight

From the Toledo Cell 2 design analysis a saturated unit weight of **127 pcf** was used. This appears to be reasonable based upon comparison to typical values in literature (Table 3-4, Bowles and 7-2, Hough).

6b. Unconsolidated Undrained Shear Strength (Q Test Shear Strength)

From the Toledo cell 2 design analysis the undrained shear strength $Su = 600$ psf. This is consistent with typical values found in literature (Table 3-4, Bowles).

6c. Consolidated Undrained Shear Strength (R Test Strength Values)

From Table 2-2, Bowles the CU friction angles vary from 14° to 20°. Assume a cohesion intercept of **400 psf** and a friction angle of **16°**

6d. Consolidated Drained Shear Strength (S Test Shear Strength)

From Table 2-2. Bowles the drained angle of internal friction varies from 20° to 42° Assume a friction angle of $0 = 30°$ and a cohesion intercept of $C = 200$ psf.

▶ 7 LAKE BOTTOM FOUNDATION (MEDIUM TO STIFF CLAY)

7a. Unit Weight

From the Toledo CDF cell 2 design analysis the saturated unit weight is **133 pcf**. From Table 3-4 of Bowles this appears to be reasonable.

7b. Unconsolidated Undrained Shear Strength (Q Test Shear Strength)

From the Toledo CDF Cell 2 design used an undrained shear strength of $Su = 840$ psf. From Table 3-4 Bowles this value appears to be on the conservative side ($Su = 1,000$ psf according to Bowles)

7c. Consolidated Undrained Shear Strength (R Test Strength Values)

From Table 2-2, Bowles the CU friction angles vary from 14° to 20°. Assume a cohesion intercept of **500 psf** and a friction angle of **18°**.

7d. Consolidated Drained Shear Strength (S Test Shear Strength)

From Table 2-2, Bowles the drained angle of internal friction varies from 20° to 42°. Assume a friction angle of $0 = 32°$ and a cohesion intercept of $C = 300$ psf.

▶ 8 LAKE BOTTOM FOUNDATION (STIFF TO VERY STIFF)

8a. Unit Weight

From the Toledo CDF cell 2 design analysis the saturated unit weight is **136 pcf**. From Table 3-4 of Bowles this appears to be reasonable

8b. Unconsolidated Undrained Shear Strength (Q Test Shear Strength)

From the Toledo CDF Cell 2 design used an undrained shear strength of $Su = 1200$ psf. From Table 3-4 Bowles this value appears to be on the conservative side ($Su = 2,000$ psf according to Bowles).

8c. Consolidated Undrained Shear Strength (R Test Strength Values)

From Table 2-2, Bowles the CU friction angles vary from 14° to 20°. Assume a cohesion intercept of **800 psf** and a friction angle of **20°**.

8d. Consolidated Drained Shear Strength (S Test Shear Strength)

From Table 2-2, Bowles the drained angle of internal friction varies from 20° to 42°. Assume a friction angle of $0 = 36°$ and a cohesion intercept of $C = 500$ psf.

Toledo CDF Long Term Management Study
Raised Dike Design

Table 5. Stability Design Parameters

Material Type	Unit Weight sat (pcf)	Unit Weight mst (pcf)	Q Test Values c (psf)	Q Test Values 0(deg)	R Test Values c (psf)	R Test Values 0(deg)	R-Bar TestValues c(psf)	R-Bar TestValues 0(deg)
Dredge Fill Foundation	102	100	400	0	200	16.0	0	28
Raised Dike Embankment Fill	131	125	1000	0	800	25	560	35
Original Dike Embankment Fill	131	125	1000	0	800	25	560	35
Original Dike Prepared Limestone	146	137	-	-	-	-	0	35
Original Dike Riprap	126	105	-	-	-	-	0	40
Lake Bottom Foundation (Medium clay)	127	122	600	0	400	16	200	30
Lake Bottom Foundation (Medium - Stiff)	133	128	840	0	500	18	300	32
Lake Bottom Foundation (Stiff-V.Stiff)	136	132	1200	0	800	20	500	36

APPENDIX F2
GEOTECHNICAL DESIGN APPENDIX

ATTACHMENT 2

STABILITY ANALYSIS COMPUTER PRINTOUTS

Heading

Toledo CDF Dike Management Study
Stability of Raised Dikes
(Parkland Buffer Dike)
Second Dike Raising -
End of Construction Case

Profile Lines

1 1 Moist Raised Dike Embankment w/16 ft Wide Access Road

33.0	31.00
48.0	38.50
64.0	38.50
79.0	31.00

2 1 Moist Raised Dike Embankment

8.00	23.50
23.00	31.00
33.00	31.00
39.00	28.00

3 2 Moist Dredged Fill

33.0	31.00
79.0	31.00
200.0	31.00

4 3 Saturated Raised Dike Embankment

31.0	23.50
39.0	28.00
48.0	23.50

5 4 Saturated Dredged Fill

39.0	28.00
200.00	28.00

6 2 Moist Dredged Fill

-200.0	23.50
8.0	23.50
31.0	23.50

7 4 Saturated Dredged Fill

-200.0	20.50
26.5	20.50
31.0	23.50
48.0	23.50

8 5 Saturated Medium to Stiff Clay Foundation

-200.00	-9.0
200.00	-9.0

9 6 Very Stiff Clay Foundation

-200.00	-28.00
200.00	-28.00

Material Properties

1   Moist Raised Dike Embankment
125.00   Moist Unit Weight Conventional Shear
1000.00   0.00
No pore pressure

2   Moist Dredged Fill
100.00   Moist Unit Weight Conventional Shear
400.00   0.00
No pore pressure

3   Saturated Raised Dike
131.00   Saturated Unit Weight
Conventional Shear
1000.00 0.00
Piezometric Line
1 Phreatic Surface

4   Saturated Dredged Fill
102.00   Saturated Unit Weight Conventional Shear
400.00   0.00
Piezometric Line
1 Phreatic Surface

5   Moist Impervious Fill
125.00   Moist Unit Weight Conventional Shear
1000.00   0.00
No pore pressure

6   Saturated Impervious Fill
131.00   Saturated Unit Weight Conventional Shear
1000.00 0.00
Piezometric Line
1 Phreatic Surface

7   Moist Armor Stone
105.00   Moist Unit Weight Conventional Shear
0.00   40.00
No pore pressure

8   Moist Prepared Limestone
137.00   Moist Unit Weight Conventional Shear
0.00   35.00
No pore pressure

9   Saturated Prepared Limestone
146.00   Saturated Unit Weight Conventional Shear
0.00   35.00
Piezometric Line
1 Phreatic Surface

10 Saturated Armor Stone
126.00   Saturated Unit Weight Conventional Shear
0.00   40.00
Piezometric Line
1 Phratic Surface

1

11 Saturated Medium Clay Foundation
  127.00   Saturated Unit Weight Linear Increase
  430.00   39.10
  Piezometric Line
  1 Phreatic Surface

12 Saturated Medium Clay
  134.00   Saturated Unit Weight Linear Increase
  698.00   39.20
  Piezometric Line
  1 Phreatic Surface

13 Saturated Medium Clay
  136.00   Saturated Unit Weight Linear Increase
  1022.00   33.80
  Piezometric Line
  1 Phraetic Surface

14 Saturated Medium Clay
  133.00   Saturated Unit Weight
  Linear Increase
  775.00   30.20
  Piezometric Line
  1 Pheartic Surface

15 Saturated Medium Clay
  132.00   Saturated Unit Weight
  Linear Increase
  516.00   28.00]
  Piezometric Line
  1 Pheartic Surface

16 Saturated Medium Clay
  132.00   Saturated Unit Weight
  Linear Increase
  516.00   28.00
  Piezometric Line
  1 Pheartic Surface

17 Very Stiff Clay
  138.00   Saturated Unit Weight
  Conventional Shear
  2500.00   0.00
  Piezometric Line
  1 Pheartic Surface

Piezometric Line Data

1   62.4 Phreatic Surface

-200.00	0.00
-73.00	0.00
-55.00	0.00
3.00	4.00
21.00	17.00
39.00	28.00
200.00	28.00

Surface Pressure

-200.00	-4.50	281.00	0.000000
-87.00	-5.00	281.00	0.000000
-84.00	-3.00	187.00	0.000000
-79.00	-3.00	187.00	0.000000
-73.00	0.00	0.00	0.000000

Analysis/Computation

  Circular   Search
  20.00   42.00   0.05000   -30.00
  TANGENT
  -12.0

PLOT Output activated
COMPUTE Results
PRINT Input Data

UTEXAS3 - VER. 1.120 - 10/08/92 -
(C) 1985-1992 S. G. WRIGHT
Date: 4:15:1998 - Time: 16:50:12 - Input file: tolrai2d
Toledo CDF Dike Management Study
Stability of Raised Dikes (Parkland Buffer Dike)
Second Dike Raising - End of Construction Case

Table No. 2 New Profile Line Data

PROFILE LINE 1 - MATERIAL TYPE = 1
Moist Raised Dike Embankment w/16 ft Wide A

Point	X	Y
1	33.000	31.000
2	48.000	38.500
3	64.000	38.500
4	79.000	31.000

PROFILE LINE 2 - MATERIAL TYPE =1
Moist Raised Dike Embankment

Point	X	Y
1	8.000	23.500
2	23.000	31.000
3	33.000	31.000
4	39.000	28.000

PROFILE LINE 3 - Material Type = 2
Moist Dredged Fill

Point	X	Y
1	33.000	31.000
2	79.000	31.000
3	200.000	31.000

PROFILE LINE 4 - MATERIAL TYPE = 3
Saturated Raised Dike Embankment

Point	X	Y
1	31.000	23.500
2	39.000	28.000
3	48.000	23.500

PROFILE LINE 5 - MATERIAL TYPE = 4
Saturated Dredged Fill

Point	X	Y
1	39.000	28 .000
2	200.000	28 .000

PROFILE LINE 6 - MATERIAL TYPE = 2
Moist Dredged Fill

Point	X	Y
1	-200.000	23.500
2	8.000	23.500
3	31.000	23.500

PROFILE LINE 7 - MATERIAL TYPE = 4
Saturated Dredged Fill

Point	X	Y
1	-200.000	20.500
2	26.500	20.500
3	31.000	23.500
4	43.000	23.500

PROFILE LINE 8 - MATERIAL TYPE = 5
Saturated Medium to Stiff Clay Foundation

Point	X	Y
1	-200.000	-9.000
2	200.000	-9.000

PROFILE LINE 9 - MATERIAL TYPE = 6
Very Stiff Clay Foundation

Point	X	Y
1	-200.000	-28.000
2	200.000	-28.000

All new profile lines defined - No old lines retained

UTEXAS3 - VER. 1.120 - 10/08/92 -
(C) 1985-1992 S. G WRIGHT
Date: 4:15:1998 - Time: 16:50:12 - Input file: tolrai2d
Toledo CDF Dike Management Study
Stability of Raised Dikes (Parkland Buffer Dike)
Second Dike Raising - End of Construction Case
Unit weight of material = 100.000

Table No. 3 NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS

DATA FOR MATERIAL TYPE 1
Moist Raised Dike Embankment
Unit weight of material = 125.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   1000.000
Friction angle   .000 degrees
No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 2
Moist Dredged Fill
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   400.000
Friction angle   .000 degrees
No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 3
Saturated Raised Dike
Unit weight of material = 131.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   1000.000
Friction angle   .000 degrees
Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 4
Saturated Dredged Fill
Unit weight of material = 102.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   400.000
Friction angle   .000 degrees
Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 5
Saturated Medium to Stiff Clay
Unit weight of material =   136.000
STRENGTH INCREASES LINEARLY WITH
DEPTH BELOW PROFILE LINE
Strength at (along) profile line   1022.000
Increase in strength per unit of depth 33.800
Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 6
Saturated Very Stiff Clay
Unit weight of material = 138.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   2500.000
Friction angle   .000 degrees
Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

All new material properties defined -
No old data retained

UTEXAS3 - VER. 1.120 - 10/08/92 -
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Date: 4:15:1998 - Time: 16:50:12 - Input file: tolrai2d
Toledo CDF Dike Management Study
Stability of Raised Dikes (Parkland Buffer Dike)
Second Dike Raising - End of Construction Case

Table No. 5 New Piezometric Line Data - Conventional/First-Stage Computations

Line No.	Point	x	Y	
1 - Unit weight of water =62.40				Phreatic Surface
1	1	-200.000	20.500	Phreatic Surface
1	2	26.500	20.500	Phreatic Surface
1	3	31.000	23.500	Phreatic Surface
1	4	39.000	28.000	Phreatic Surface
1	5	200.000	28.000	Phreatic Surface

Table No. 21 1-Stage Final Critical Circle Information

X Coordinate of Center 20.550
Y Coordinate of Center 52.050
Radius 55.450
Factor of Safety 1.513
Side Force Inclination . . . . Horiz.
Number of circles tried 380
No. of circles F caic. for 380

UTEXAS3 - VER. 1.120 - 10/08/92 -
(C) 1985-1992 5. G WRIGHT
Date: 4:15:1998 - Time: 16:50:12 - Input file: tolrai2d
Toledo CDF Dike Management Study
Stability of Raised Dikes (Parkland Buffer Dike)
Second Dike Raising - End of Construction Case

HEADING
Toledo CDF Dike Management Study
Stability of Raised Dikes (Parkland Buffer Dike)
Second Dike Raising - Long Term Case (Dike Filled)

PROFILE LINES

1 1 Moist Raised Dike Embankment w/16 ft Wide A

33.00	31.00
48.00	38.50
64.00	38.50
70.00	35.50

2 2 Moist Dredged Fill

64.00	38.50
200.00	38.50

3 3 Saturated Raised Dike Embankment

48.00	31.00
70.00	35.50
79.00	31.00

4 4 Saturated Dredged Fill

70.00	35.50
200.00	35.50

5 1 Moist Raised Dike Embankment

8.00	23.50
23.00	31.00
33.00	31.00
39.00	28.00

6 2 Moist Dredged Fill

33.00	31.00
48.00	31.00

7 3 Saturated Raised Dike Embankment

31.00	23.50
39.00	28.00
48.00	23.50

8 4 Saturated Dredged Fill

39.00	28.00
48.00	31.00
200.00	31.00

9 2 Moist Dredged Fill

-200.00	23.50
8.00	23.50
31.00	23.50

10 4 Saturated Dredged Fill

-200.00	20.50
26.50	20.50
31.00	23.50
48.00	23.50
200.00	23.50

11 5 Saturated Medium to Stiff Clay Foundation

-200.00	-9.00
200.00	-9.00

12 6 Very Stiff Clay Foundation

-200.00	-28.00
200.00	-28.00

MATERIAL PROPERTIES

1 Moist Raised Dike Embankment
125.00   Moist Unit Weight Conventional Shear
560.00   35.00
No pore pressure

2 Moist Dredged Fill
100.00   Moist Unit Weight Conventional Shear
0.00   28.00
No pore pressure

3 Saturated Raised Dike
131.00   Saturated Unit Weight Conventional Shear
560.00   35.00
Piezometric Line
1 Phreatic Surface

4 Saturated Dredged Fill
102.00   Saturated Unit Weight Conventional Shear
0.00   .28.00
Piezometric Line
1 Phreatic Surface

5 Saturated Medium to Stiff Clay
136.00   Saturated Unit Weight Linear Increase
200.00   30.00
Piezometric Line
1 Phreatic Surface

6 Saturated Very Stiff Clay
138.00   Saturated Unit Weight Conventional Shear
500.00   36.00
Piezometric Line
1 Phreatic Surface

PIEZOMETRIC LINE DATA

1	62.4	Phreatic Surface
	-200.00	20.50
	26.50	20.50
	31.00	23.50
	39.00	28.00
	48.00	31.00
	70.00	35.50
	200.00	35.50

ANALYSIS/COMPUTATION

Circular		Search	
35.00	42.00	0.05000	-30.00
TANGENT			
20.00			

PROCEDURE FOR COMPUTATION OF F
Bishop' s Procedure

PLOT Output activated
COMPUTE Results
PRINT Input Data

5

Critical Failure Surface (FDS = 1.513)

TABLE NO. 2 NEW PROFILE LINE DATA

PROFILE LINE 1 - MATERIAL TYPE = 1
Moist Raised Dike Embankment w/16 ft Wide A

Point	x	y
1	33.000	31.000
2	48. 000	38. 500
3	64.000	38. 500
4	70. 000	35.500

PROFILE LINE 2 - MATERIAL TYPE = 2
Moist Dredged Fill

Point	x	y
1	64 000	38.500
2	200.000	38.500

PROFILE LINE 3 - MATERIAL TYPE = 3
Saturated Raised Dike Embankment

Point	x	y
1	48.000	31.000
2	70. 000	35.500
3	79. 000	31. 000

PROFILE LINE 4 - MATERIAL TYPE = 4
Saturated Dredged Fill

Point	x	y
1	70.000	35.500
2	200.000	35.500

PROFILE LINE 5 - MATERIAL TYPE =
Moist Raised Dike Embankment

Point	x	y
1	8.000	23.500
2	23.000	31.000
3	33.000	31.000
4	39.000	28.000

PROFILE LINE 6 - MATERIAL TYPE = 2
Moist Dredged Fill

Point	x	y
1	33.000	31.000
2	48.000	31.000

PROFILE LINE 7 - MATERIAL TYPE =
Saturated Raised Dike Embankment

Point	x	y
1	31.000	23.500
2	39.000	28.000
3	48.000	23.500

PROFILE LINE 8 - MATERIAL TYPE = 4
Saturated Dredged Fill

Point	x	y
1	39.000	28.000
2	48.000	31.000
3	200.000	31.000

PROFILE LINE 9 - MATERIAL TYPE = 2
Moist Dredged Fill

Point	x	y
1	-200.000	23.500
2	8.000	23.500
3	31.000	23.500

PROFILE LINE 10 - MATERIAL TYPE = 4
Saturated Dredged Fill

Point	x	y
1	-200.000	20.500
2	26.500	20.500
3	31.000	23.500
4	48.000	23.500
5	200.000	23.500

PROFILE LINE 11 - MATERIAL TYPE = 5
Saturated Medium to Stiff Clay Foundation

Point	x	y
1	-200.000	-9.000
2	200.000	-9.000

PROFILE LINE 12 - MATERIAL TYPE = 6
Very Stiff Clay Foundation

Point	x	y
1	-200.000	-28.000
2	200.000	-28.000

All new profile lines defined - No old lines retained

UTEXAS3 - VER. 1.120 - 10/08/92 -
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Date: 4:16:1998 - Time: 7:46:21 - Input file: tolrai2d
Toledo CDF Dike Management Study
Stability of Raised Dikes (Parkland Buffer Dike)
Second Dike Raising - Long Term Case (Dike Filled)

Table No. 3 New Material Property Data - Conventional/First-Stage Computations

DATA FOR MATERIAL TYPE 1
Moist Raised Dike Embankment
Unit weight of material = 125.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   560.000
Friction angle   35.000 degrees
No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 2
Moist Dredged Fill
Unit weight of material = 100.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   .000
Friction angle   28.000 degrees
No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 3
Saturated Raised Dike
Unit weight of material = 131.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   560.000
Friction angle   35.000 degrees
Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 4
Saturated Dredged Fill
Unit weight of material = 102.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   .000
Friction angle   28.000 degrees
Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE S
Saturated Medium to Stiff Clay
Unit weight of material =   136.000
STRENGTH INCREASES LINEARLY WITH DEPTH BELOW PROFILE LINE
Strength at (along) profile line   200.000
Increase in strength per unit of depth   30.000
Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 6
Saturated Very Stiff Clay
Unit weight of material = 138.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   500.000
Friction angle   36.000 degrees
Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

All new material properties defined -
No old data retained

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Stability of Raised Dikes (Parkland Buffer Dike)
Second Dike Raising - Long Term Case (Dike Filled)

Table No. 5 NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS

Line No.	Point	x	Y	
1 - Unit weight of water = 62.40				Phreatic Surface
1	1	-200.000	20.500	Phreatic Surface
1	2	26.500	20.500	Phreatic Surface
1	3	31.000	23.500	Phreatic Surface
1	4	39.000	28.000	Phreatic Surface
1	5	48.000	31.000	Phreatic Surface
1	6	70.000	35.500	Phreatic Surface
1	7	200.000	35.500	Phreatic Surface

All new piezometric lines defined -
No old lines retained

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Table No. 15 New Analysis/Computation Data

Circular Shear Surface(s)
Automatic Search Performed
Starting Center Coordinate for Search at - X = 35.000
$\hspace{11.5cm}$ Y = 42.000

Required accuracy for critical center (= minimum spacing between grid points) = .050

Critical shear surface not allowed to pass below Y = -30.000

For the initial mode of search all circles are tangent to horizontal line at Y = 20.000

Procedure used to compute the factor of safety: BISHOP

THE FOLLOWING REPRESENT EITHER DEFAULT OR PREVIOUSLY DEFINED VALUES:

Initial trial estimate for the factor of safety = 3.000

Maximum number of iterations allowed for calculating the factor of safety = 40

Allowed force imbalance for convergence = 100.000

Allowed moment imbalance for convergence = 100.000

Initial trial values for factor of safety (and side force inclination for Spencer's procedure) will be kept constant during search

Maximum subtended angle to be used for subdivision of the circle into slices = 3.00 degrees
$\hspace{9cm}$ Depth of crack = .000

Search will be continued to locate a more critical shear surface (if one exists) after the initial mode is complete

Depth of water in crack $\quad$ = $\quad$ .000
Unit weight of water in crack $\;$ = $\;$ 62.400
Seismic coefficient $\qquad$ = $\quad$ .000

Conventional (single-stage) computations to be performed

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Table No. 16 NEW SLOPE GEOMETRY DATA

NOTE - No Data were input, slope geometry data were generated by the program

Slope Coordinates -

Point	X	Y
1	-200.000	23.500
2	8.000	23.500
3	23.000	31.000
4	33.000	31.000
5	48.000	38.500
6	64.000	38.500
7	200.000	38.500

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Table No. 21 1-Stage Final Critical Circle Information

X Coordinate of Center	21.750
Y Coordinate of Center	68.650
Radius	57.450
Factor of Safety	1.932
Side Force Inclination	Horiz.
Number of circles tried	351
No. of circles F calc. for	351

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HEADING

Toledo CDF Dike Management Study
Stability of Raised Dikes
Second Dike Raising - End of Construction Case

PROFILE LINES

1 1 Raised Dike Embankment
33.0	31.00
48.0	38.50
58.0	38.50
73.0	31.00

2 1 Raised Dike Embankment
8.00	23.50
23.00	31.00
33.00	31.00
39.00	28.00

3 2 Moist Dredged Fill
33.0	31.00
73.0	31.00
200.0	31.00

4 3 Saturated Raised Dike Embankment
31.0	23.50
39.0	28.00
48.0	23.50

5 4 Saturated Dredged Fill
39.0	28.00
200.00	28.00

6 2 Moist Dredged Fill
8.0	23.50
31.0	23.50

7 4 Saturated Dredged Fill
21.0	17.00
31.0	23.50
48.0	23.50

8 5 Moist Impervious Fill
-35.00	10.00
-27.00	14.00
-8.00	23.50
8.00	23.50
21.00	17.00

9 6 Saturated Impervious Fill
3.00	4.00
21.00	17.00
35.00	10.00

10 7 Moist Armor Stone
-73.00	0.00
-71.00	1.00
-66.00	1.00
-40.00	14.0O
-27.00	14.00

11 8 Moist Prepared Limestone
-55.00	0.00
-35.00	10.00
-25.00	10.00
-13.00	4.00
3.00	4.00

12 9 Saturated Prepared Limestone
-87.00	-5.00
-65.00	-5.00
-55.00	0.00
3.00	4.00
13.00	4.00
25.00	10.00
35.00	10.00
64.00	-4.50

13 10 Saturated Armor Stone
-87.00	-5.00
-84.00	-3.00
-79.00	-3.00
-73.00	0.00
-55.00	0.00

14 11 Saturated Medium Clay Foundation
-200.00	-4.50
-87.00	-5.00
-84.00	-7.50
-70.00	-8.00
-60.00	-8.30

15 12 Saturated Medium Clay Foundation

-60.00	-8.30
-50.00	-8.50
-40.00	-8.60

16 13 Saturated Medium Clay Foundation

-40.00	-8.60
0.00	-8.00
10.00	-9.00

17 14 Saturated Medium Clay Foundation

10.00	-9.00
20.00	-9.00
40.00	-7.00
50.00	-5.80

18 15 Saturated Medium Clay Foundation

50.00	-5.80
64.00	-4.50

19 16 Saturated Medium Clay Foundation

64.00	-4.50
200.00	-4.50

20 17 Very Stiff Clay Foundation

-200.00	-28.00
200.00	-28:00

Material Properties

1 Moist Raised Dike Embankment
125.00   Moist Unit Weight Conventional Shear
1000.00   0.00
No pore pressure

2 Moist Dredged Fill
100.00   Moist Unit Weight Conventional Shear
400.00   0.00
No pore pressure

3 Saturated Raised Dike
131.00   Saturated Unit Weight Conventional Shear
1000.00 0.00
Piezometric Line
1 Phreatic Surface

4 Saturated Dredged Fill
102.00   Saturated Unit Weight Conventional Shear
400.00   0.00
Piezometric Line
1 Phreatic Surface

5 Moist Impervious Fill
125.00   Moist Unit Weight Conventional Shear
1000.00   0.00
No pore pressure

6 Saturated Impervious Fill
131.00   Saturated Unit Weight Conventional Shear
1000.00 0.30
Piezometric Line
1 Phreatic Surface

7 Moist Armor Stone
105.00   Moist Unit Weight Conventional Shear
0.00   40.00
No pore pressure

8 Moist Prepared Limestone
137.00   Moist Unit Weight Conventional Shear
0.00   35.00
No pore pressure

9 Saturated Prepared Limestone
146.00   Saturated Unit Weight Conventional Shear
0.00   35.00
Piezometric Line
1 Phreatic Surface

10 Saturated Armor Stone
126.00   Saturated Unit Weight Conventional Shear
0.00   40.00
Piezometric Line
1 Phratic Surface

11 Saturated Medium Clay Foundation
127.00   Saturated Unit Weight Linear Increase
430.00   39.10
1 Phreatic Surface

12 Saturated Medium Clay
134.00   Saturated Unit Weight Linear Increase
698.00   39.20
Piezometric Line
1 Phreatic Surface

13 Saturated Medium Clay
136.00   Saturated Unit Weight Linear Increase
1022.00 33.80
Piezometric Line
1 Phraetic Surface

14 Saturated Medium Clay
133.00   Saturated Unit Weight Linear Increase
775.00   30.20
Piezometric Line
1 Pheartic Surface

15 Saturated Medium Clay
132.00   Saturated Unit Weight Linear Increase
516.00   28.00
Piezometric Line
1 Pheartic Surface

16 Saturated Medium Clay
132.00   Saturated Unit Weight Linear Increase
516.00   28.00
Piezometric Line
1 Pheartic Surface

17 Very Stiff Clay
138.00   Saturated Unit Weight Conventional Shear
2500.00   0.00
Piezometric Line
1 Pheartic Surface

PIEZOMETRIC LINE DATA

1 62.4	Phreatic Surface
-200.00	0.00
-73.00	0.00
-55.00	0.00
3.00	4.00
21.00	17.00
39.00	28.00
200.00	28.00

SURFACE PRESSURE

-200.00	-4.50	281.00	0.000000
-87.00	-5.00	281.00	0.000000
-84.00	-3.00	187.00	0.000000
-79.00	-3.00	187.00	0.000000
-73.00	0.00	0.00	0.000000

ANALYSIS/COMPUTATION

Circular		Search	
20.00	42.00	0.05000	-30.00
TANGENT			
12.0			

PLOT Output activated
COMPUTE Results
PRINT Input Data

Critical Failure Surface (FDS = 1.932)

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Table No. 2   NEW PROFILE LINE DATA

PROFILE LINE 1 - MATERIAL TYPE = 1
Raised Dike Embankment

Point	X	Y
1	33.000	31.000
2	48.000	38.500
3	58.000	38.500
4	73.000	31.000

PROFILE LINE 2 - MATERIAL TYPE =
Raised Dike Embankment

Point	X	Y
1	8.000	23.500
2	23.000	31.000
3	33.000	31.000
4	39.000	28.000

PROFILE LINE 3 - MATERIAL TYPE = 2
Moist Dredged Fill

Point	x	y
1	33.000	31.000
2	73.000	31.000
3	200.000	31.000

PROFILE LINE 4 - MATERIAL TYPE = 3
Saturated Raised Dike Embankment

Point	x	y
1	31.000	23.500
2	39.000	28.000
3	48.000	23.500

PROFILE LINE 5 - MATERIAL TYPE = 4
Saturated Dredged Fill

Point	x	y
1	39.000	28.000
2	200.000	28.000

PROFILE LINE 6 - MATERIAL TYPE = 2
Moist Dredged Fill

Point	x	y
1	8.000	23.500
2	31.000	23.500

PROFILE LINE 7 - MATERIAL TYPE = 4
Saturated Dredged Fill

Point	x	y
1	21.000	17.000
2	31.000	23.500
3	48.000	23.500

PROFILE LINE 8 - MATERIAL TYPE = 5
Moist Impervious Fill

Point	x	y
1	-35.000	10.000
2	-27.000	14.000
3	-8.000	23.500
4	8.000	23.500
5	21.000	17.000

PROFILE LINE 9 - MATERIAL TYPE = 6
Saturated Impervious Fill

Point	x	y
1	3.000	4.000
2	21.000	17.000
3	35.000	10.000

PROFILE LINE 10 - MATERIAL TYPE = 7
Moist Armor Stone

Point	x	y
1	-73.000	.000
2	-71.000	1.000
3	-66.000	1.000
4	-40.000	14.000
5	-27.000	14.000

PROFILE LINE 11 - MATERIAL TYPE = 8
Moist Prepared Limestone

Point	x	y
1	-55.000	.000
2	-35.000	10.000
3	-25.000	10.000
4	-13.000	4.000
5	3.000	4.000

PROFILE LINE 12 - MATERIAL TYPE = 9
Saturated Prepared Limestone

Point	x	y
1	-87.000	-5.000
2	-65.000	-5.000
3	-55.000	.000
4	3.000	4.000
5	13.000	4.000
6	25.000	10.000
7	35.000	10.000
8	64.000	-4.500

14

PROFILE LINE 13 - MATERIAL TYPE = 10
Saturated Armor Stone

Point	X	Y
1	-87.000	-5.000
2	-84.000	-3.000
3	-79.000	-3.000
4	-73.000	.000
5	-55.000	.000

PROFILE LINE 14 - MATERIAL TYPE = 11
Saturated Medium Clay Foundation

Point	X	Y
1	-200.000	-4.500
2	-87.000	-5.000
3	-84.000	-7.500
4	-70.000	-8.000
5	-60.000	-8.300

PROFILE LINE 15 - MATERIAL TYPE = 12
Saturated Medium Clay Foundation

Point	X	Y
1	-60.000	-8.300
2	-50.000	-8.500
3	-40.000	-8.600

PROFILE LINE 16 - MATERIAL TYPE = 13
Saturated Medium Clay Foundation

Point	X	Y
1	-40.000	-8.600
2	.000	-9.000
3	10.000	-9.000

PROFILE LINE 17 - MATERIAL TYPE = 14
Saturated Medium Clay Foundation

Point	X	Y
1	10.000	-9.000
2	20.000	-9.000
3	40.000	-7.000
4	50.000	-5.800

PROFILE LINE 18 - MATERIAL TYPE = 15
Saturated Medium Clay Foundation

Point	X	Y
1	50.000	-5.800
2	64.000	-4.500

PROFILE LINE 19 - MATERIAL TYPE = 16
Saturated Medium Clay Foundation

Point	X	Y
1	64.000	-4.500
2	200.000	-4.500

PROFILE LINE 20 - MATERIAL TYPE = 17
Very Stiff Clay Foundation

Point	X	Y
1	-200.000	-28.000
2	200.000	-28.000

All new profile lines defined - No old lines retained

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Second Dike Raising - End of Construction Case

Table No. 3   NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS

DATA FOR MATERIAL TYPE 1
Moist Raised Dike Embankment
Unit weight of material = 125.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   1000.000
Friction angle   .000 degrees
No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 2
Moist Dredged Fill
Unit weight of material = 100.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   400.000
Friction angle   .000 degrees
No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 3
Saturated Raised Dike
Unit weight of material = 131.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   1000.000
Friction angle   .000 degrees

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 4
Saturated Dredged Fill
Unit weight of material = 102.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   400.000
Friction angle   .000 degrees

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

15

DATA FOR MATERIAL TYPE 5
Moist Impervious Fill

    Unit weight of material = 125.000
    CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
    Cohesion   1000.000
    Friction angle   .000 degrees
    No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 6
Saturated Impervious Fill

    Unit weight of material = 131.000
    CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
    Cohesion   1000.000
    Friction angle   .000 degrees

    Pore water pressures defined by piezometric line
    Number of the piezometric line used = 1
    Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 7
Moist Armor Stone

    Unit weight of material = 105.000
    CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
    Cohesion   .000
    Friction angle   40.000 degrees
    No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 8
Moist Prepared Limestone

    Unit weight of material = 137.000
    CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
    Cohesion   .000
    Friction angle   35.000 degrees
    No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 9
Saturated Prepared Limestone

    Unit weight of material = 146.000
    CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
    Cohesion   .000
    Friction angle   35.000 degrees

    Pore water pressures defined by piezometric line
    Number of the piezometric line used = 1
    Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 10
Saturated Armor Stone

    Unit weight of material = 126.000
    CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
    Cohesion   .000
    Fiction angle   40.000 degrees

    Pore water pressures defined by piezometric line
    Number of the piezometric line used = 1
    Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 11
Saturated Medium Clay Foundation

    Unit weight of material = 127.000
    STRENGTH INCREASES LINEARLY
    WITH DEPTH BELOW PROFILE LINE
    Strength at (along) profile line430.000
    Increase in strength per unit of depth - 39.100

    Pore water pressures defined by piezometric line
    Number of the piezometric line used = 1
    Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 12
Saturated Medium Clay

    Unit weight of material = 134.000
    STRENGTH INCREASES LINEARLY
    WITH DEPTH BELOW PROFILE LINE
    Strength at (along) profile line698.000

    Increase in strength per unit of depth - 39.200
    Pore water pressures defined by piezometric line
    Number of the piezometric line used = 1
    Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 13
Saturated Medium Clay

    Unit weight of material = 136.000
    STRENGTH INCREASES LINEARLY
    WITH DEPTH BELOW PROFILE LINE
    Strength at (along) profile line1022.000
    Increase in strength per unit of depth   33.800

    Pore water pressures defined by piezometric line
    Number of the piezometric line used = 1
    Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 14
Saturated Medium Clay

    Unit weight of material = 133.000
    STRENGTH INCREASES LINEARLY
    WITH DEPTH BELOW PROFILE LINE
    Strength at (along) profile line775.000
    Increase in strength per unit of depth - 30.200

    Pore water pressures defined by piezometric line
    Number of the piezometric line used = 1
    Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 15
Saturated Medium Clay

    Unit weight of material = 132.000
    STRENGTH INCREASES LINEARLY
    WITH DEPTH BELOW PROFILE LINE
    Strength at (along) profile line516.000
    Increase in strength per unit of depth - 28.000

    Pore water pressures defined by piezometric line
    Number of the piezometric line used = 1
    Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 16
Saturated Medium Clay
  Unit weight of material = 132.000
  STRENGTH INCREASES LINEARLY
  WITH DEPTH BELOW PROFILE LINE
  Strength at (along) profile line516.000
  Increase in strength per unit of depth - 28.000

  Pore water pressures defined by piezometric line
  Number of the piezometric line used = 1
  Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 17
Very Stiff Clay
  Unit weight of material = 138.000
  CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
  Cohesion   2500.000
  Friction angle   .000 degrees

  Pore water pressures defined by piezometric line
  Number of the piezometr~c line used = 1
  Negative pore pressures set to zero

  All new material properties defined -
  No old data retained

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Table No. 5 NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS

Line No.	Point	x	Y	
1 - Unit weight of water		62.40		Phreatic Surface
1	1	-200.000	.000	Phreatic Surface
1	2	-73.000	.000	Phreatic Surface
1	3	-55.000	.000	Phreatic Surface
1	4	3.000	4.000	Phreatic Surface
1	5	21.000	17.000	Phreatic Surface
1	6	39.000	28.000	Phreatic Surface
1	7	200.000	28.000	Phreatic Surface

  All new piezometric lines defined -
  No old lines retained

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Table No. 10 NEW SURFACE PRESSURE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS

ALL NEW DATA INPUT - NO OLD DATA RETAINED

Surface Pressures -

Point	X	Y	Normal Pressure	Shear Stress
1	-200.000	-4.500	281.000	.000
2	-87.000	-5.000	281.000	.000
3	-84.000	-3.000	187.000	.000
4	-79.000	-3.000	187.000	.000
5	-73.000	.000	.000	.000

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Table No. 21 1-STAGE FINAL CRITICAL CIRCLE INFORMATION

X Coordinate of Center	-27.550
Y Coordinate of Center	93.850
Radius	115.350
Factor of Safety	1.443
Side Force Inclination	10.64
Number of circles tried	511
No. of circles F calc. for	511

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Critical Failure Surface (FDS = 1.443)

18 12 Medium to Stiff Clay (100% Consolidated)

    -200.00   -11.00
     200.00   -11.00

19 13 Very Stiff Clay (100% Consolidated)

    -200.00   -28.00
     200.00   -28.00

Material Properties

1   Moist Raised Dike Embankment

    125.00   Moist Unit Weight Conventional Shear
    560.00   35.00
    No pore pressure

2   Moist Dredged Fill

    100.00   Moist Unit Weight Conventional Shear
    400.00   0.00
    No pore pressure

3   Saturated Raised Dike

    131.00   Saturated Unit Weight Conventional Shear
    1000.00   0.00
    Piezometric Line
    1 Phreatic Surface

4   Saturated Dredged Fill

    102.00   Saturated Unit Weight Conventional Shear
    400.00   0.00
    Piezometric Line
    1 Phreatic Surface

5   Moist Impervious Fill

    125.00   Moist Unit Weight Conventional Shear
    1000.00   0.00
    No pore pressure

6   Saturated Impervious Fill

    131.00   Saturated Unit Weight Conventional Shear
    1000.00   0.00
    Piezometric Line
    1 Phreatic Surface

7   Moist Armor Stone

    105.00   Moist Unit Weight Conventional Shear
    0.00   40.00
    No pore pressure

8   Moist Prepared Limestone

    137.00   Moist Unit Weight Conventional Shear
    0.00   35.00
    No pore pressure

9   Saturated Prepared Limestone

    146.00   Saturated Unit Weight Conventional Shear
    0.00   35.00
    Piezometric Line
    1 Phreatic Surface

10 Saturated Armor Stone

    126.00   Saturated Unit Weight Conventional Shear
    0.00   40.00
    Piezometric Line
    1 Phratic Surface

11 Saturated Medium Clay Foundation (100% Consolidated)

    136.00   Saturated Unit Weight Conventional Shear
    200   30
    Piezometric Line
    1 Phreatic Surface

12 Saturated Medium to Stiff Clay Foundation (100% Consolidated)

    136.00   Saturated Unit Weight Conventional Shear
    300   32
    Piezometric Line
    1 Phreatic Surface

13 Saturated Stiff Clay (100% Consolidated)

    138.00   Saturated Unit Weight Conventional Shear
    500   36
    Piezometric Line
    1 Phraetic Surface

PIEZOMETRIC LINE DATA

1 62.4 Phreatic Surface

-200.00	0.00
-73.00	0.00
-55.00	0.00
3.00	4.00
21.00	17.00
31.00	23.50
39.00	28.00
48.00	31.00
64.00	35.5
200.00	35.5

SURFACE PRESSURE

-200.00	-4.50	281.00	0.000000
-87.00	-5.00	281.00	0.000000
-84.00	-3.00	187.00	0.000000
-79.00	-3.00	187.00	0.000000
-73.00	0.00	0.00	0.000000

ANALYSIS/COMPUTATION

Circular Search

20.00	42.00	0.05000	-30.00

TANGENT

-12.00

PLOT Output activated
COMPUTE Results
PRINT Input Data

UTEXAS3 - VER. 1.120 - 10/08/92 -
(C) 1985-1992 5. G. WRIGHT
Date: 4:15:1998 - Time: 11:51:56 - Input file: tolrai2c
Toledo CDF Dike Management Study
Stability of Raised Dikes
Second Dike Raising - Long Term Case (Dike Filled)

Table No. 2 NEW PROFILE LINE DATA

PROFILE LINE 1 - MATERIAL TYPE = 1
Raised Moist Dike Embankment

Point	x	y
1	33.000	31.000
2	48.000	38.500
3	58.000	38.500
4	64.000	35.500

PROFILE LINE 2 - MATERIAL TYPE = 2
Moist Dredged Fill

Point	x	y
1	58.000	38.500
2	200.000	38.500

PROFILE LINE 3 - MATERIAL TYPE = 4
Saturated Dredged Fill

Point	x	y
1	64.000	35.500
2	200.000	35.500

PROFILE LINE 4 - MATERIAL TYPE = 3
Saturated Raised Dike Fill

Point	x	y
1	48.000	31.000
2	64.000	35.500
3	73.000	31.000

PROFILE LINE 5 - MATERIAL TYPE = 1
Raised Moist Dike Embankment

Point	x	y
1	18.000	23.500
2	23.000	31.000
3	33.000	31.000
4	39.000	28.000

PROFILE LINE 6 - MATERIAL TYPE = 2
Moist Dredged Fill

Point	x	y
1	33.000	31.000
2	48.000	31.000

PROFILE LINE 7 - MATERIAL PE = 4
Saturated Dredged Fill

Point	x	y
1	39.000	28.000
2	48.000	31.000
3	73.000	31.000
4	200.000	31.000

PROFILE LINE 8 - MATERIAL TYPE =
Saturated Raised Dike Embankment

Point	x	y
1	31.000	23.500
2	39.000	28.000
3	48.000	23.500

PROFILE LINE 9 - MATERIAL TYPE = 4
Saturated Dredged Fill

Point	x	y
1	21.000	17.000
2	31.000	23.500
3	48.000	23.500

PROFILE LINE 10 - MATERIAL TYPE = 2
Moist Dredged Fill

Point	x	y
1	8.000	23.500
2	31.000	23.500

PROFILE LINE 11 - MATERIAL TYPE = 5
Moist Impervious Fill

Point	x	y
1	-35.000	10.000
2	-27.000	14.000
3	-8.000	23.500
4	8.000	23.500
5	21.000	17.000

PROFILE LINE 12 - MATERIAL TYPE = 6
Saturated Impervious Fill

Point	x	y
1	3.000	4.000
2	21.000	17.000
3	35.000	10.000

PROFILE LINE 13 - MATERIAL TYPE = 7
Moist Armor Stone

Point	x	y
1	-73.000	.000
2	-71.000	1.000
3	-66.000	1.000
4	-40.000	14.000
5	-27.000	14.000

PROFILE LINE 14 - MATERIAL TYPE = 8
Moist Prepared Limestone

Point	x	y
1	-55.000	.000
2	-35.000	10.000
3	-25.000	10.000
4	-13.000	4.000
5	3.000	4.000

PROFILE LINE 15 - MATERIAL TYPE = 9
Saturated Prepared Limestone

Point	x	y
1	-87.000	-5.000
2	-65.000	-5.000
3	-55.000	.000
4	3.000	4.000
5	13.000	4.000
6	25.000	10.000
7	35.000	10.000
8	64.000	-4.500

PROFILE LINE 16 - MATERIAL TYPE = 10
Saturated Armor Stone

Point	x	y
1	-87.000	-5.000
2	-84.000	-3.000
3	-79.000	-3.000
4	-73.000	.000
5	-55.000	.000

PROFILE LINE 17 - MATERIAL TYPE = 11
Saturated Medium Clay Foundation (100% Consolidated)

Point	x	y
1	-200.000	-4.500
2	-87.000	-5.000
3	-84.000	-7.500
4	-50.000	-8.500
5	.000	-9.000
6	20.000	-9.000
7	50.000	-7.000
8	64.000	-4.500
9	200.000	-4.500

PROFILE LINE 18 - MATERIAL TYPE = 12
Medium to Stiff Clay (100% Consolidated)

Point	x	y
1	-200.000	-11.000
2	200.000	-11.000

PROFILE LINE 19 - MATERIAL TYPE = 13
Very Stiff Clay (100% Consolidated)

Point	x	y
1	-200.000	-28.000
2	200.000	-28.000

All new profile lines defined - No old lines retained

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Toledo CDF Dike Management Study
Stability of Raised Dikes
Second Dike Raising - Long Term Case (Dike Filled)

Table No. 3 NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS

DATA FOR MATERIAL TYPE 1
Moist Raised Dike Embankment
Unit weight of material = 125.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   560.000
Friction angle   35.000 degrees

No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 2
Moist Dredged Fill
Unit weight of material = 100.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   400.000
Friction angle   .000 degrees

No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 3
Saturated Raised Dike
Unit weight of material = 131.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   1000.000
Friction angle   .000 degrees

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 4
Saturated Dredged Fill
Unit weight of material = 102.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion 400.000
Friction angle .000 degrees

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 5
Moist Impervious Fill
Unit weight of material = 125.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion 1000.000
Friction angle .000 degrees

No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 6
Saturated Impervious Fill

Unit weight of material = 131.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion 1000.000
Friction angle .000 degrees

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 7
Moist Armor Stone
Unit weight of material = 105.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion .000
Friction angle 40.000 degrees

No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 8
Moist Prepared Limestone
Unit weight of material = 137.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion .000
Friction angle 35.000 degrees

No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 9
Saturated Prepared Limestone
Unit weight of material = 146.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion .000
Friction angle 35.000 degrees

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 10
Saturated Armor Stone
Unit weight of material = 126.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion .000
Friction angle 40.000 degrees

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FUR MATERIAL TYPE 11
Saturated Medium Clay Foundation (100's Consolidated)
Unit weight of material = 136.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion 200.000
Friction angle 30.000 degrees

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 12
Saturated Medium to Stiff Clay Foundation (100% Consolidated)
Unit weight of material = 136.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion 300.000
Friction angle 32.000 degrees

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 13
Saturated Stiff Clay (100% Consolidated)
Unit weight of material = 138.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion 500.000
Friction angle 36.000 degrees

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

All new material properties defined -
No old data retained

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Toledo CDF Dike Management Study
Stability of Raised Dikes
Second Dike Raising - Long Term Case (Dike Filled)

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Table No. 5 NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS

Line

No.	Point	x	y	
1 - Unit weight of water =62.40				
1	1	-200.000	.000	Phreatic Surface
1	2	-73.000	.000	Phreatic Surface
1	3	-55.000	.000	Phreatic Surface
1	4	3.000	4.000	Phreatic Surface
1	5	21.000	17.000	Phreatic Surface
1	6	31.000	23.500	Phreatic Surface
1	7	39.000	28.000	Phreatic Surface
1	8	48.000	31.000	Phreatic Surface
1	9	64.000	35.500	Phreatic Surface
1	10	200.000	35.500	Phreatic Surface

All new piezometric lines defined -
No old lines retained

UTEXAS3 - VER. 1.120 - 10/08/92 -
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Toledo CDF Dike Management Study
Stability of Raised Dikes
Second Dike Raising - Long Term Case (Dike Filled)1

Table No. 10 NEW SURFACE PRESSURE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS

ALL NEW DATA INPUT - NO OLD DATA RETAINED

Surface Pressures -

Point	X	y	Normal Pressure	Shear Stress
1	-200.000	-4.500	281.000	.000
2	-87.000	-5.000	281.000	.000
3	-84.000	-3.000	187.000	.000
4	-79.000	-3.000	187.000	.000
5	-73.000	.000	.000	.000

UTEXAS3 - VER. 1.120 - 10/08/92 -
(C) 1985-1992 5. G WRIGHT
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Toledo CDF Dike Management Study
Stability of Raised Dikes
Second Dike Raising - Long Term Case (Dike Filled)

Table No. 21 1-STAGE FINAL CRITICAL CIRCLE INFORMATION

X Coordinate of Center	-41.750
Y Coordinate of Center	162.650
Radius	173.650
Factor of Safety	2.121
Side Force Inclination	13.73
Number of circles tried	514
No. of circles F caic. for	514

UTEXAS3 - VER. 1.120 - 10/08/92 - (C) 1985-1992 5. G WRIGHT
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Toledo CDF Dike Management Study
Stability of Raised Dikes
Second Dike Raising - Long Term Case (P4.'.e Filled)

Critical Failure Surface (FDS = 2.121)

HEADING

Toledo CDF Long Term Study
Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

PROFILE LINES

1 1 MOIST DREDGE FILL

-200.00	31.00
33.00	31.00
48.00	31.00
64.00	31.00
79.00	31.00
200.00	31.00

2 2 SAT DREDGE FILL

-200.00	28.00
200.00	28.00

3 3 MEDIUM TO STIFF CLAY FOUNDATION

-200.00	-4.50
200.00	-4.50

MATERIAL PROPERTIES

1 MOIST DREDGE FILL
100.00   MOIST UNIT WEIGHT
Conventional Shear
400.00   0.00
No pore pressure

2 SAT DREDGE FILL
102.00   SAT UNIT WEIGHT
Conventional Shear
400.00   0.00
Piezometric Line
1 WATER TABLE

3 SAT MEDIUM STIFF CLAY FOUNDATION
134.00
Linear increase
430.00   39.10
Piezometric Line
1 WATER TABLE

PIEZOMETRIC LINE DATA

1	62.4	WATER TABLE
	-200.00	28.00
	200.00	28.00

SURFACE PRESSURE

-200.00	31.00	0.00	0.000000
33.00	31.00	0.00	0.000000
48.00	31.00	938.00	0.000000
64.00	31.00	938.00	0.000000
79.00	31.00	0.00	0.000000
200.00	31.00	0.00	0.000000

ANALYSIS/COMPUTATION

Circular		Search	
64.00	40.00	0.50000	-4.50

TANGENT
28.00

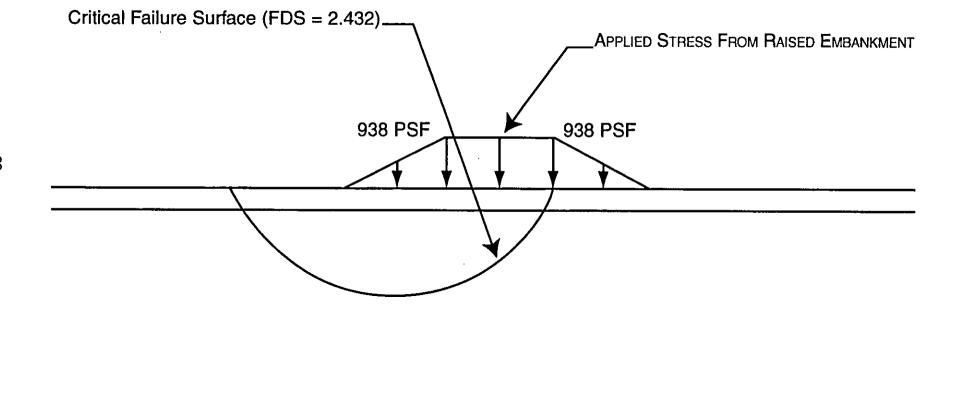PLOT Output activated
COMPUTE Results
PRINT Input Data

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(C) 1985-1992 S. G. WRIGHT
Date: 4:23:1998 - Time: 8:42:59 - Input file: TOLBC1
Toledo CDF Long Term Study
Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

Table No. 2   NEW PROFILE LINE DATA

PROFILE LINE 1 - MATERIAL TYPE = 1
MOIST DREDGE FILL

Point	X	Y
1	-200.000	31.000
2	33.000	31.000
3	48.000	31.000
4	64.000	31.000
5	79.000	31.000
6	200.000	31.000

PROFILE LINE 2 - MATERIAL TYPE = 2
SAT DREDGE FILL

Point	X	Y
1	-200.000	28.000
2	200.000	28.000

PROFILE LINE 3 - MATERIAL TYPE = 3
MEDIUM TO STIFF CLAY FOUNDATION

Point	X	Y
1	-200.000	-4.500
2	200.000	-4.500

All new profile lines defined - No old lines retained

UTEXAS3 - VER. 1.120 - 10/08/92 -
(C) 1985-1992 S. G. WRIGHT
Date: 4:23:1998 - Time: 8:42:59 - Input file: TOLBC1
Toledo CDF Long Term Study
Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

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Table No. 3 NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS

DATA FOR MATERIAL TYPE 1
MOIST DREDGE FILL
Unit weight of material = 100.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   400.000
Friction angle   .000 degrees
No (or zero) pore water pressures

DATA FOR MATERIAL TYPE 2
SAT DREDGE FILL
Unit weight of material = 102.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   400.000
Friction angle   .000 degrees

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 3
SAT MEDIUM STIFF CLAY FOUNDATION
Unit weight of material =   134.000
STRENGTH INCREASES LINEARLY
WITH DEPTH BELOW PROFILE LINE
Strength at (along) profile line   430.000
Increase in strength per unit of depth - 39.100

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

All new material properties defined -
No old data retained

UTEXAS3 - VER. 1.120 - 10/08/92 -
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Date: 4:23:1998 - Time: 8:42:59 - Input file: TOLBC1
Toledo CDF Long Term Study
Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

Table No. 5 NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS

Line No.	Point	x	y	
1 - Unit weight of water =62.40				WATER TABLE
1	1	-200.000	28.000	WATER TABLE
1	2	200.000	28.000	WATER TABLE

All new piezometric lines defined -
No old lines retained

UTEXAS3 - VER. 1.120 - 10/08/92 -
(C) 1985-1992 5. G WRIGHT
Date: 4:23:1998 - Time: 8:42:59 - Input file: TOLBC1
Toledo CDF Long Term Study
Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

Table No. 10 NEW SURFACE PRESSURE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS ALL NEW DATA INPUT - NO OLD DATA RETAINED

Surface Pressures -

Point	X	Y	Normal Pressure	Shear Stress
1	-200.000	31.000	.000	.000
2	33.000	31.000	.000	.000
3	48.000	31.000	938.000	.000
4	64.000	31.000	938.000	.000
5	79.000	31.000	.000	.000
6	200.000	31.000	.000	.000

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Date: 4:23:1998 - Time: 8:42:59 - Input file: TOLBC1
Toledo CDF Long Term Study
Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

Table No. 21 1-STAGE FINAL CRITICAL CIRCLE INFORMATION

X Coordinate of Center	40.000
Y Coordinate of Center	41.500
Radius	26.500
Factor of Safety	2.432
Side Force Inclination	1.45
Number of circles tried	451
No. of circles F calc. for	343

• CAUTION • FACTOR OF SAFETY COULD NOT BE COMPUTED FOR SOME OF GRID POINTS AROUND THE MINIMUM • RESULTS MAY BE ERRONEOUS

UTEXAS3 - VER. 1.120 - 10/08/92 -
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Date: 4:23:1998 - Time: 8:42:59 - Input file: TOLBC1
Toledo CDF Long Term Study
Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

Critical Failure Surface (FDS = 2.432)

APPLIED STRESS FROM RAISED EMBANKMENT

938 PSF   938 PSF

HEADING

Toledo CDF Long Term Study
Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

PROFILE LINES

1 1 MOIST DREDGE FILL

-200.00	23.50
8.00	23.50
38.00	23.50
54.00	23.50
84.00	23.50
200.00	23.50

2 2 SAT DREDGE FILL

-200.00	20.50
200.00	20.50

3 3 MEDIUM TO STIFF CLAY FOUNDATION

-200.00	-4.50
200.00	-4.50

MATERIAL PROPERTIES

1   MOIST DREDGE FILL
100.00   MOIST UNIT WEIGHT
Conventional Shear
400.00   0.00
No pore pressure

2   SAT DREDGE FILL
102.00   SAT UNIT WEIGHT
Conventional Shear
400.00   0.00
Piezometric Line
1 WATER TABLE

3   SAT MEDIUM STIFF CLAY FOUNDATION
134   .00
Linear increase
430.00   39.10
Piezometric Line
1 WATER TABLE

PIEZOMETRIC LINE DATA

1	62.4	WATER TABLE
	-200.00	20.50
	200.00	20.50

SURFACE PRESSURE

-200.00	23.50	0.00	0.000000
8.00	23.50	0.00	0.000000
38.00	23.50	1875.00	0.000000
54.00	23.50	1875.00	0.000000
84.00	23.50	0.00	0.000000
200.00	23.50	0.00	0.000000

ANALYSIS/COMPUTATION

Circular Search

54.00	28.00	0.50000	-4.50

TANGENT
20.00

PLOT Output activated
COMPUTE Results
PRINT Input Data

UTEXAS3 - VER. 1.120 - 10/08/92 -
(C) 1985-1992 S. G WRIGHT
Date: 4:23:1998 - Time: 9: 5: 5 - Input file: TOLBC2
Toledo CDF Long Term Management Study
Computation of Bearing Capacity of Raised Dike
Single Dike Raising - End of Construction

Table No. 2   NEW PROFILE LINE DATA

PROFILE LINE 1 - MATERIAL TYPE = 1
MOIST DREDGE FILL

Point	X	Y
1	-200.000	23.500
2	8.000	23.500
3	38.000	23.500
4	54.000	23.500
5	84.000	23.500
6	200.000	23.500

PROFILE LINE 2 - MATERIAL TYPE = 2
SAT DREDGE FILL

Point	X	Y
1	-200.000	20.500
2	200.000	20.500

PROFILE LINE 3 - MATERIAL TYPE = 3
MEDIUM TO STIFF CLAY FOUNDATION

Point	X	Y
1	-200.000	-4.500
2	200.000	-4.500

All new profile lines defined - No old lines retained

UTEXAS3 - VER. 1.120 - 10/08/92 -
(C) 1985-1992 5. G WRIGHT
Date: 4:23:1998 - Time: 9: 5: 5 - Input file: TOLBC2
Toledo CDF Long Term Management Study
Computation of Bearing Capacity of Raised Dike
Single Dike Raising - End of Construction

Table No. 3 NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATION

DATA FOR MATERIAL TYPE 1
MOIST DREDGE FILL
Unit weight of material = 100.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS

Cohesion   400.000
Friction angle   .000 degrees
No (or zero) pore water pressures]

DATA FOR MATERIAL TYPE 2
SAT DREDGE FILL
Unit weight of material = 102.000
CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion   400.000
Friction angle   .000 degrees

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

DATA FOR MATERIAL TYPE 3
SAT MEDIUM STIFF CLAY FOUNDATION
Unit weight of material = 134.000
STRENGTH INCREASES LINEARLY
WITH DEPTH BELOW PROFILE LINE
Strength at (along) profile line430.000
Increase in strength per unit of depth - + 39.100

Pore water pressures defined by piezometric line
Number of the piezometric line used = 1
Negative pore pressures set to zero

All new material properties defined -
No old data retained

UTEXAS3 - VER. 1.120 - 10/08/92 -
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Date: 1:23:1998 - Time: 9: 5: 5 - Input file: TOLBC2
Toledo CDF Long Term Study
Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

Table No.5 NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS

Line No.	Point	x	Y	
1 - Unit weight of water =62.40				WATER TABLE
1	1	-200.000	20.500	WATER TABLE
1	2	200.000	20.500	WATER TABLE

All new piezometric lines defined -
No old lines retained

UTEXAS3 - VER. 1.120 - 10/08/92 -
(C) 1985-1992 5. G WRIGHT
Date: 4:23:1998 - Time: 9: 5: 5 - Input file: TOLBC2
Toledo CDF Long Term Study
Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

Table No. 10 NEW SURFACE PRESSURE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS ALL NEW DATA INPUT - NO OLD DATA RETAINED

Depth of crack -000

Search will be continued to locate a more critical shear surface (if one exists) after the initial mode is complete

Depth of water in crack = .000

Unit weight of water in crack = 62.400

Seismic coefficient = .000

Conventional (single-stage) computations to be performed

Procedure used to compute the factor of safety: SPENCER

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Date: 4:23:1998 - Time: 9: 5: 5 - Input file: TOLBC2
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Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

Table No. 16 NEW SLOPE GEOMETRY DATA

NOTE - NO DATA WERE INPUT, SLOPE GEOMETRY DATA WERE GENERATED BY THE PROGRAM

Slope Coordinates -

Point	X	Y
1	-200.000	23.500
2	8.000	23.500
3	38.000	23.500
4	54.000	23.500
5	84.000	23.500
6	200.000	23.500

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Date: 4:23:1998 - Time: 9: 5: 5 - Input file: TOLBC2
Toledo CDF Long Term Study
Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

Surface Pressures -

Point	X	Y	Normal Pressure	Shear Stress
1	-200.000	23.500	.000	.000
2	8.000	23.500	.000	.000
3	38.000	23.500	1875.000	.000
4	54.000	23.500	1875.000	.000
5	84.000	23.500	.000	.000
6	200.000	23.500	.000	.000

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Date: 4:23:1998 - Time: 9: 5: 5 - Input file: TOLBC2
Toledo CDF Long Term Study
Computation of Bearing Capacity of Raised Dike
Double Dike Raising - End of Construction

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Table No. 15 NEW ANALYSIS/COMPUTATION DATA

Circular Shear Surface(s)

Automatic Search Performed

Starting Center Coordinate for Search at -   X = 54.000
                                               Y = 28.000

Required accuracy for critical center (= minimum spacing between grid points) = .500

Critical shear surface not allowed to pass below $Y = -4.500$

For the initial mode of search all circles are tangent to horizontal line at - $Y = 20.000$

THE FOLLOWING REPRESENT EITHER DEFAULT OR PREVIOUSLY DEFINED VALUES:

Initial trial estimate for the factor of safety =   3.000

Initial trial estimate for side force inclination =   15.000 degrees
(Applicable to Spencer's procedure only)

Maximum number of iterations allowed for calculating the factor of safety = 40

Allowed force imbalance for convergence =   100.000

Allowed moment imbalance for convergence =   100.000

Initial trial values for factor of safety (and side force inclination for Spencer's procedure) will be kept constant during search

Maximum subtended angle to be used for subdivision of the circle into slices = 3.00 degrees

At the end of the current mode of search the most critical circle which was found has the following values -

      X-center = 21.00   Y-center = 38.50   Radius = 38.00

Factor of Safety =   1.263   Side Force Inclination =   1.86

UTEXAS3 - VER. 1.120 - 10/08/92 - (C) 1985-1992 5. G. WRIGHT
Date: 4:23:1998 - Time: 9: 5: 5 - Input file: TOLBC2
TOLEDO CDF LONG TERM MANAGEMENT STUDY
COMPUTATION OF BEARING CAPACITY OF RAISED DIKE
SINGLE DIKE RAISING - END OF CONSTRUCTION

Table No. 21 1-STAGE FINAL CRITICAL CIRCLE INFORMATION

X Coordinate of Center	21.000
Y Coordinate of Center	38.500
Radius	38.000
Factor of Safety	1.263
Side Force Inclination	1.86
Number of circles tried	129
No. of circles F calc. for	107

UTEXAS3 - VER. 1.120 - 10/08/92 - (C) 1985-1992 5. G. WRIGHT
Date: 4:23:1998 - Time: 9: 5: 5 - Input file: TOLBC2
TOLEDO CDF LONG TERM MANAGEMENT STUDY
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SINGLE DIKE RAISING - END OF CONSTRUCTION

APPENDIX F2
GEOTECHNICAL DESIGN APPENDIX

ATTACHMENT 3

SETTLEMENT ANALYSIS COMPUTER PRINTOUTS

PROGRAM CSETT - VERTICAL STRESS INDUCTION AND SETTLEMENT PROGRAM
DATE: 98/04/22 TIME: 11.45.46

◤A▶ INPUT DATA

A1. TITLE - TOLEDO RAISED DIKE SETTLEMENT (DOUBLE RAISED, TOP DIKE)

A2. BOUSSINES Q SOLUTION WILL BE USED TO COMPUTE INDUCED STRESSES. THE MAXIMUM DEPTH TO WHICH THE ANALYSIS WILL BE EXTENDED IS 60.00 FEET.

A3. 2-DIMENSIONAL PRESSURE LOAD DATA NONE

A4. 2-DIMENSIONAL SOIL LOAD DATA

PROFILE NUMBER 1:
NUMBER OF POINTS= 4
BEGINNING TIME OF APPLICATION = 2.0000 YRS.
ENDING TIME OF APPLICATION = 3.0000 YRS.
EFFECTIVE UNIT WEIGHT OF SOIL LOAD = 100.00 PCF

POINT NO.	X (FT.)	Y (FT.)
1	33.00	599.60
2	48.00	607.10
3	64.00	607.10
4	200.00	607.10

PROFILE NUMBER 2:
NUMBER OF POINTS= 4
BEGINNING TIME OF APPLICATION = .0000 YRS.
ENDING TIME OF APPLICATION = .0080 YRS.
EFFECTIVE UNIT WEIGHT OF SOIL LOAD= 125.00 PCF

POINT NO.	X (FT.)	Y (FT.)
1	33.00	599.60
2	48.00	607.10
3	64.00	607.10
4	70.00	604.10

PROFILE NUMBER 3:
NUMBER OF POINTS= 3
BEGINNING TIME OF APPLICATION = .0000 YRS.
ENDING TIME OF APPLICATION = 2.0000 YRS.
EFFECTIVE UNIT WEIGHT OF SOIL LOAD= 102.00 PCF

POINT NO.	X (FT.)	Y (FT.)
1	48.00	599.60
2	70.00	604.10
3	200.00	604.10

PROFILE NUMBER 4:
NUMBER OF POINTS= 3
BEGINNING TIME OF APPLICATION = .0000 YRS.
ENDING TIME OF APPLICATION = .0080 YRS.
EFFECTIVE UNIT WEIGHT OF SOIL LOAD= 131.00 PCF

POINT NO.	X (FT.)	Y (FT.)
1	48.00	599.60
2	70.00	604.10
3	79.00	599.60

A5. 3-DIMENSIONAL RECTANGULAR LOAD DATA
NONE

A6. 3-DIMENSIONAL IRREGULAR LOAD DATA
NONE

A7. EXCAVATION DATA
NONE

A8. SOIL DATA

STRATA NO.	EL. OF TOP OF STRATUM (FEET NGVD)	DRAINAGE CONDITION	EFF UNIT WEIGHT (PCF)	RECOMPR. INDEX	COEF.OF CONSOL. (SQFT/YR)	POISSON'S RATIO
1	599.60	D	37.60	.08000	10.10000	.50000
2	564.10	D	73.60	.08000	10.10000	.50000

A9. STRESS-STRAIN DATA

STRATUM NO.   1
COMPRESSION INDEX =   .34200
RECOMPRESS ION INDEX =   .08000
INSITU VOID RATIO =   1.60000
INSITU OVERBURDEN = 702.90 PSF

STRATUM NO.   2

VOID RATIO	PRESSURE (PSF)
.5070	60.0000
.4790	1000.0000
.2620	64000.0000

A10. TIME SEQUENCE FOR CONSOLIDATION CALCULATIONS
TIME RATE OF CONSOLIDATION CALCULATIONS WILL BE MADE AT TIMES (YRS):

1.00
5.00
10.00
20.00
30.00
50.00
70.00
80.00

A11. OUTPUT CONTROL DATA
XXL =   40.0000 FT.
XUL =   100.0000 FT.
DELX =   10.0000 FT.

PROGRAM CSETT - VERTICAL STRESS INDUCTION AND SETTLEMENT PROGRAM
DATE: 98/04/22 TIME: 11.59.37

1. TITLE- TOLEDO RAISED DIKE SETTLEMENT (DOUBLE RAISED, TOP DIKE)

POSITION: X= -10.0

2. SUMMARY OF ULTIMATE SETTLEMENTS

STRATA NO. (FEET)	MID-DEPTH OF STRATA (LB/SQ FT)	IN - SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (FEET)	ULTIMATE SETTLEMENT
1	17.75	667.40	11.47	.021
2	47.75	2236.40	68.03	.027

3. TIME-SETTLEMENT SUMMARY

(SETTLEMENT IN FEET AT SPECIFIEDTIMES)

STRATA NO.	ULT	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	20.00 (YRS.)	30.00 (YRS.)	40.00 (YRS.)	50.00 (YRS.)	70.00 (YRS.)	80.00 (YRS.)
1	.021	.002	.009	.013	.018	.018	.021	.021	.021	.021
2	.027	.000	.009	.009	.009	.018	.018	.018	.018	.023
Totals:	.048	.002	.018	.022	.027	.036	.039	.039	.039	.044

POSITION: X = .0

2. SUMMARY OF ULTIMATE SETTLEMENTS

STRATA NO. (FEET)	MID-DEPTH OF STRATA (LB/SQ FT)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (FEET)	ULTIMATE SETTLEMENT
1	17.75	667.40	19.72	.037
2	47.75	2236.40	99.20	.036

3.TIME-SETTLEMENT SUMMARY

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO.	ULT	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	20.00 (YRS.)	30.00 (YRS.)	40.00 (YRS.)	50.00 (YRS.)	70.00 (YRS.)	80.00 (YRS.)
1	.037	.006	.015	.021	.030	.032	.034	.036	.036	.037
2	.036	.000	.009	.009	.018	.018	.027	.027	.032	.036
TOTALS:	.073	.006	.024	.030	.048	.050	.061	.063	.068	.073

2. SUMMARY OF ULTIMATE SETTLEMENTS

STRATA NO. (FEET)	MID-DEPTH OF STRATA (LB/SQ FT)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (FEET)	ULTIMATE SETTLEMENT
1	17.75	667.40	36.63	.066
2	47.75	2236.40	146.21	.058

3. TIME-SETTLEMENT SUMMARY

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO.	ULT	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	20.00 (YRS.)	30.00 (YRS.)	40.00 (YRS.)	50.00 (YRS.)	70.00 (YRS.)	80.00 (YRS.)
1	.066	.010	.027	.041	.056	.061	.064	.066	.066	.066
2	.058	.001	.010	.018	.027	.032	.037	.041	.047	.049
TOTALS:	.124	.011	.037	.059	.083	.093	.101	.107	.113	.115

2. SUMMARY OF ULTIMATE SETTLEMENTS

STRATA NO. (FEET)	MID-DEPTH OF STRATA (LB/SQ FT)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (FEET)	ULTIMATE SETTLEMENT
1	17.75	667.40	74.34	.132
2	47.75	2236.40	214.61	.085

3. TIME-SETTLEMENT SUMMARY

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO	ULT	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	20.00 (YRS.)	30.00 (YRS.)	40.00 (YRS.)	50.00 (YRS.)	70.00 (YRS.)	80.00 (YRS.)
1	.132	.020	.057	.081	.110	.122	.129	.130	.131	.132
2	.085	.006	.019	.026	.038	.046	.054	.060	.067	.071
TOTALS:	.217	.026	.076	.107	.148	.168	.183	.190	.198	.203

2. SUMMARY OF ULTIMATE SETTLEMENTS

STRATA NO. (FEET)	MID-DEPTH OF STRATA (LB/SQ FT)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (FEET)	ULTIMATE SETTLEMENT
1	17.75	667.40	168.17	.293
2	47.75	2236.40	306.22	.120

3. TIME-SETTLEMENT SUMMARY

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO.	ULT	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	20.00 (YRS.)	30.00 (YRS.)	40.00 (YRS.)	50.00	70.00	80.00
1	.293	.051	.128	.182	.242	.270	.282	.287	.292	.292
2	.120	.009	.026	.038	.053	.067	.077	.085	.095	.101
TOTALS:	.413	.060	.154	.220	.295	.337	.359	.372	.387	.393

2. SUMMARY OF ULTIMATE SETTLEMENTS

STRATA NO. (FEET)	MID-DEPTH OF STRATA (LB/SQ FT)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (FEET)	ULTIMATE SETTLEMENT
1	17.75	667.40	441.19	.750
2	47.75	2236.40	412.24	.156

3. TIME-SETTLEMENT SUMMARY

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO	ULT	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	20.00 (YRS.)	30.00 (YRS.)	40.00 (YRS.)	50.00 (YRS.)	70.00 (YRS.)	80.00 (YRS.)
1	.750	.137	.330	.470	.624	.692	.724	.738	.748	.750
2	.156	.011	.035	.049	.072	.088	.101	.112	.128	.132
TOTALS:	.906	.148	.365	.519	.696	.780	.825	.882	.850	.876

2. SUMMARY OF ULTIMATE SETTLEMENTS

STRATA NO. (FEET)	MID-DEPTH OF STRATA (LB/SQ FT)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (FEET)	ULTIMATE SETTLEMENT
1	17.75	667.40	728.49	1.248
2	47.75	2236.40	512.04	.193

3. TIME-SETTLEMENT SUMMARY

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO.	ULT	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	20.00 (YRS.)	30.00 (YRS.)	40.00 (YRS.)	50.00 (YRS.)	70.00 (YRS.)	80.00 (YRS.)
1	1.248	.225	.547	.778	1.035	1.153	1.205	1.229	1.244	1.247
2	.193	.011	.040	.060	.088	.107	.124	.137	.157	.163
TOTALS:	1.441	.236	.587	.838	1.123	1.260	1.329	1.366	1.401	1.410

2. SUMMARY OF ULTIMATE SETTLEMENTS

STRATA NO. (FEET)	MID-DEPTH OF STRATA (LB/SQ FT)	IN - SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (FEET)	ULTIMATE SETTLEMENT
1	17.75	667.40	812.93	1.368
2	47.75	2236.40	584.84	.218

3. TIME-SETTLEMENT SUMMARY

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO.	ULT	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	20.00 (YRS.)	30.00 (YRS.)	40.00 (YRS.)	50.00 (YRS.)	70.00 (YRS.)	80.00 (YRS.)
1	1.368	.215	.582	.841	1.128	1.260	1.316	1.344	1.362	1.367
2	.218	.009	.043	.067	.097	.123	.138	.153	.175	.184
TOTALS:	1.586	.224	.625	.908	1.225	1.383	1.454	1.497	1.537	1.551

2. SUMMARY OF ULTIMATE SETTLEMENTS

STRATA NO. (FEET)	MID-DEPTH OF STRATA (LB/SQ FT)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (FEET)	ULTIMATE SETTLEMENT
1	17.75	667.40	771.68	1.290
2	47.75	2236.40	623.88	.230

3. TIME-SETTLEMENT SUMMARY

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO.	ULT	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	20.00 (YRS.)	30.00 (YRS.)	40.00 (YRS.)	50.00 (YRS.)	70.00 (YRS.)	80.00 (YRS.)
1	1.290	.089	.478	.753	1.048	1.179	1.240	1.269	1.285	1.289
2	.230	.004	.044	.069	.103	.126	.146	.161	.186	.195
TOTALS:	1.520	.093	.522	.822	1.151	1.305	1.386	1.430	1.471	1.484

2. SUMMARY OF ULTIMATE SETTLEMENTS

STRATA NO. (FEET)	MID-DEPTH OF STRATA (LB/SQ FT)	IN - SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (FEET)	ULTIMATE SETTLEMENT
1	17.75	667.40	687.54	1.134
2	47.75	2236.40	637.09	.233

3. TIME-SETTLEMENT SUMMARY

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO	ULT	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	20.00 (YRS.)	30.00 (YRS.)	40.00 (YRS.)	50.00 (YRS.)	70.00 (YRS.)	80.00 (YRS.)
1	1.134	-.053	.351	.617	.901	1.030	1.085	1.111	1.130	1.133
2	.233	.000	.043	.069	.104	.128	.147	.164	.188	.196
TOTALS:	1.367	-.053	.394	.686	1.005	1.158	1.232	1.275	1.318	1.329

2. SUMMARY OF ULTIMATE SETTLEMENTS

STRATA NO. (FEET)	MID-DEPTH OF STRATA (LB/SQ FT)	IN - SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (LB/SQ FT)	ULTIMATE SETTLEMENT
1	17.75	667.40	660.37	1.092
2	47.75	2236.40	637.17	.234

3. TIME-SETTLEMENT SUMMARY

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO	ULT	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	20.00 (YRS.)	30.00 (YRS.)	40.00 (YRS.)	50.00 (YRS.)	70.00 (YRS.)	80.00 (YRS.)
1	1.092	-.101	.308	.579	.859	.986	1.044	1.071	1.088	1.089
2	.234	-.004	.040	.069	.102	.128	.147	.164	.188	.196
TOTALS:	1.326	-.105	.348	.648	.961	1.114	1.191	1.235	1.276	1.285

2. SUMMARY OF ULTIMATE SETTLEMENTS

STRATA NO. (FEET)	MID-DEPTH OF STRATA (LB/SQ FT)	IN-SITU OVERBURDEN (LB/SQ FT)	DELTA SIGMA (FEET)	ULTIMATE SETTLEMENT
1	17.75	667.40	650.64	1.077
2	47.75	2236.40	632.84	.232

3. TIME-SETTLEMENT SUMMARY

(SETTLEMENT IN FEET AT SPECIFIED TIMES)

STRATA NO	ULT	1.00 (YRS.)	5.00 (YRS.)	10.00 (YRS.)	20.00 (YRS.)	30.00 (YRS.)	40.00 (YRS.)	50.00 (YRS.)	70.00 (YRS.)	80.00 (YRS.)
1	1.077	-.119	.294	.563	.846	.973	1.030	1.058	1.075	1.076
2	.232	-.009	.038	.066	.102	.126	.146	.163	.187	.194
TOTALS:	1.309	-.128	.332	.629	.948	1.099	1.176	1.221	1.262	1.270

Appendix F2
Geotechnical Design Appendix

ATTACHMENT 4

BEARING CAPACITY

ANALYSIS COMPUTER PRINTOUT

Critical Failure Surface (FDS = 1.263) ———

APPLIED EMBANKMENT STRESS DISTRIBUTION

1875 PSF   1875 PSF